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ABSTRACT

The purpose of this study was to assess the effectiveness of Elementary Science Study (ESS) materials for developing creativity in children. Three hypotheses were formulated to the effect that children who receive ESS instruction will achieve higher scores on Torrance Tests of Creative Thinking (TTCT) Figural and Verbal, and on the investigator's test of Observation and Classification. The sample consisted of four third-grade classes in two elementary schools with heterogeneous populations. After the pre-test, two classrooms were selected as the experimental group and the remainder served as a control. Four ESS units were taught in the experimental classrooms over a period of eight weeks while regular instruction went on as usual in the control classrooms. The pre- and posttests were scored for nine different measures and analyzed using the one-way analysis of covariance. On the basis of this analysis two hypotheses were accepted, while the third, which was rejected, gave some evidence of significant results. The outcome of the study was quite conclusive, indicating that ESS materials are useful for promoting creativity in elementary school children. (Author/JR)

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CREATIVITY AND ELEMENTARY SCIENCE STUDY MATERIALS

by

Piyush Swami

Accepted in Partial Completion

of the Requirements for the Degree

Master of Education

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SE 016 519

CREATIVITY AND ELEMENTARY SCIENCE STUDY MATERIALS

A Thesis

Presented to

The Faculty of

Western Washington State College

In Partial Fulfillment

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July 1972

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"At least one-half of the jobs that primary children in our schools today will fill as adults in our economic society of the future have not yet been created."

Chapter 1

INTRODUCTION

"My thesis," said Edward Lindaman, former Director of Program Planning of the Apollo Space Exploration Project, NASA, in an enlightening speech, "is that the space station . . . will be to the twenty-first century what the plow has been to all centuries preceding us in terms of utility and its impact on civilization."[1] The statement is an eyeopener and seems to have far-reaching implications for the present and the future. The future will bring different kinds of problems from anything we have seen in the past about life, communication, food, environment and education.

A high priority must be placed on preparation for the future. Research for space exploration may be conducted by scientists in research laboratories, but the world citizen of tomorrow will also have a changed life style. He must have an enlarged perspective. The kinds of problems faced and the consequences of his choices for their solutions will no longer be a matter of concern for him, his country or other countries in the world, as the case is now, but for a bigger part of the universe. We do not understand today what these life situations will be. However, one way to use our present to meet the future successfully is to prepare individuals who can meet challenges themselves.

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[1]Opinion expressed by Dr. Edward Lindaman in an address at St. James Presbyterian Church, Bellingham, Washington, February 13, 1972.

The present educational training, based heavily on knowledge, may not be of much use in the future. Individuals who can think, imagine and devise their own ways to meet unfamiliar situations will be needed. In changed and unfamiliar situations, individuals will be required to function in divergent ways to meet challenges successfully. The talent required for thinking, acting and living divergently, which is commonly designated as creative abilities or creativity, must be identified and promoted.

The knowledge or and interest in the development of creative talents are relatively new, as pointed out by Guilford.[2] In the history of civilization creative abilities were considered as signs of madness, irrationality, divine power or super intelligence (genius). Recent interest, however, has brought out significant knowledge about the nature of creativity. Creative abilities are no longer considered as signs of deviated brain activity compared to normal human beings. Creativity is considered as a normal activity of the brain. Creative talents are functions of normal, healthy brains, just like any other talents of the brain. It is in this spirit that Sister Corita said "creativity is to relate."[3] It suggests that creative individuals have been able to give expression to their potential creative talents. The majority of people have, one way or the other, succumbed to pressures from different sources to suppress their creative abilities. It is in

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[2]J. P. Guilford, "Creativity," American Psychologist, Vol. 5 (Sept. 1950), pp. 444-54.

[3]Sister Corita, Footnotes and Headlines (New York: Herder and Herder, 1967), p. 24.

this that educational training can help an individual to identify and promote the development of creative talent.

Several researches have confirmed that schools can help prepare more creative individuals. The evidences are substantial. A number of models have been suggested which can be followed for training. Other researches conducted have given a new insight into the nature of the problems of a creative individual in terms of his social adjustment and self-motivation. Details of these studies will be discussed in Chapter 2. Briefly, it can be summarized here that creativity has evoked considerable interest among educationists, psychologists, industrialists and all other segments of the society. Research conclusions have provided an indication that the goals for the development of creative individuals are not only necessary but attainable.

The raison d'être of this study is to look for and look at measuring creativity in the present educational system.

STATEMENT OF THE PROBLEM

The specific purpose of this study is to examine the effectiveness of Elementary Science Study (ESS) materials in developing creative thinking in third grade children.

DEFINITION OF TERMS USED

1. Creativity is the process of sensing difficulties, problems, gaps in information, making guesses or formulating hypotheses about such deficiencies, testing these guesses, possibly revising and retesting them, and finally communicating the results.

2. Elementary Science Study (ESS) materials are science units developed and published for elementary schools by the Elementary Science Study of Education Development Center, Inc., 55 Chapel Street, Newton, Massachusetts, 02160.

The term "ESS materials," when used in this study, refers to all the parts of it including the teachers' guides, kits and informational materials.

3. Fluency refers to the total number of responses relevant to the questions asked.

4. Flexibility encompasses the different kinds of responses given by the individual to a certain question.

5. Originality denotes the statistically infrequent responses given by the individual for a certain question.

6. Elaboration connotes the additional ideas added by the individual to the primary response in answer to a particular question.

DESIGN AND METHOD

The population of the study consisted of third grade boys and girls of two typical elementary schools with two classrooms in each building. These schools were located and functioning under the Bellingham Public Schools system.

In each of the two selected schools, two third grade classrooms were selected for the study. A battery of pre-tests, which included Torrance Tests of Creative Thinking (Figural and Verbal) and the test of Observation and Classification made by the investigator, was given to children in the four classrooms chosen for the study.

Then, two classrooms (one in each building) were regarded as experimental and the other two as the control group. For the next eight weeks of school the experimental classrooms proceeded with activities from Elementary Science Study (ESS) materials in addition to the usual science instruction. ESS materials were not introduced in the control classrooms during these eight weeks. Instruction in the control classroom was carried out in the usual manner. In all the classrooms the regular teachers conducted the classes. After a period of eight weeks, a battery of post-tests was given to the children in all four classrooms. The post-test battery included the alternate forms of the same tests which were used in the pre-test. Pre- and post-tests were given by the locally trained test administrators according to laid-out procedures in the manuals accompanying the tests.

The scoring of tests was partly carried out locally and partly by the regular testing center for the Torrance tests.[4] The scoring procedures for the test of Observation and Classification were developed by the investigator himself and are included in the appendix. The Figural forms of the Torrance Tests of Creative Thinking were scored for fluency, flexibility, originality and elaboration. The Verbal forms of the TTCT were scored for fluency, flexibility, and originality. The test of Observation and Classification was scored for fluency and flexibility in both the pre- and post-test administrations.

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[4]The Verbal forms of the Torrance Tests of Creative Thinking were scored by the trained staff at the Department of Educational Psychology, The University of Georgia, Athens, Georgia. The staff functions under the direction of E. Paul Torrance, the author of the tests.

ANALYSIS

In all, there were seven sets of scores on the Torrance Tests of Creative Thinking (Figural and Verbal forms) and two sets of scores for the test of Observation and Classification. The analyses of data were performed using analyses of covariance. In addition, the descriptive summary tables for the class mean scores were set up in order to observe the trends of data from pre- and post-tests. The facilities available at the Computer Center of Western Washington State College were used for the analysis procedures.

Chapter 2

REVIEW OF LITERATURE

DEFINITIONS

Creativity like "love" is a many splendored thing.[1] Educationists have followed different approaches to identify creative individuals from non-creative ones. For a long period of time the criterion of "product" to mark creativity has been accepted among others, such as "process," and "interaction with environment." The creative individuals were recognized with their contributions in the form of ideas, theories, poetry, gadgets, paintings and any other new contributions. Obviously, such people were given a special place in the society because of their ability. The product, however, took time to produce; it did not happen all at once.[2] In the conception and making of the product there were several attempts, stages, phases, transitions, failures, or revisions. Thus creativity must be thought of as a process of planning, experiencing, and acting by the person who is creating the product. In addition to creativity as product and process, it has been

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[1] J. P. Guilford, "Potentiality for Creativity and its Measurement," Invitational Conference on Testing Problems (New Jersey: Educational Testing Service, 1962), p. 15.

[2] Harold H. Anderson, "On the Meaning of Creativity," Creativity in Childhood and Adolescence, ed. H. H. Anderson (Palo Alto, Calif.: Science and Behavior Books, Inc., 1965), p. 46.

regarded as "freeing" one's own ideas or spontaneous behavior.[3] When the environment does not pose any danger, an individual's spontaneous behavior may be regarded as creativity. Creativity is the result of harmonious interaction with the environment. Creativity is a development process. The term creativity has been identified with several hundred words, some of which are "originality," "novel," "flexibility," "adaptive," "serendipity," and so on.

E. Paul Torrance defined creativity in a comprehensive manner as a process of sensing difficulties, problems, gaps in information, making guesses or formulating hypotheses about such deficiencies, testing these guesses, possibly revising and retesting them, and finally communicating the results. Torrance conceived in this definition notions such as creating something new, adventurous thinking, "getting away from the main track," "breaking out of the mold," "curiosity," "imagination," experimentation and exploration.[4]

STRUCTURE OF INTELLECT

J. P. Guilford has stated that creativity should be regarded as ability or abilities-based phenomenon. Whether or not an individual achieves creative products of any consequence depends upon his abilities.[5] Factor analytic studies conducted on thousands of subjects have

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[3] Ibid., p. 47.

[4] E. Paul Torrance, "Creative Thinking Through School Experiences," A Source Book for Creative Thinking, eds. S. J. Parnes and H. F. Harding (New York: Charles Scribners, 1962), p. 32.

[5] J. P. Guilford, "A Psychometric Approach to Creativity," Creativity in Childhood and Adolescence, ed. H. H. Anderson (Palo Alto, Calif.: Science and Behavior Books, Inc., 1965), p. 3.

resulted in the diagrammatic presentation of the morphological model called the "Structure of Intellect."

The model has three parameters which are content, product and operation. Each intellectual action of an individual is divided into these categories. The interaction of five kinds of operations with six different types of products and four types of content categories together form a total of 120 kinds of intellectual abilities. The five operations in the model are Cognition, Memory, Divergent Production, Convergent Production, and Evaluation. Of these, the abilities in the Divergent Production category have the most to offer for creative actions.[6] It does not, however, exclude other abilities, besides Divergent Production operations, which are responsible for creative actions. As a matter of fact, under certain circumstances almost any intellectual ability may be contributory to creative behavior.

Creative abilities which are seen in the form of fluency, flexibility, originality, and elaboration mainly belong to the Divergent Production and the Transformation layer in Product parameter.[7] The factor analytic studies and the "Structure of Intellect" suggest that creativity is not shared by a selected few but by all humanity. Every individual has the potential for being creative.[8] Those individuals

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[6]J. P. Guilford, The Nature of Human Intelligence (New York: McGraw-Hill, 1967), pp. 60-345.

[7]J. P. Guilford, "The Nature of Creativity," Intelligence, Creativity & Learning: Proceedings of the 1960 Summer Conference, eds. J. Alan Ross and Ralph Thompson (Bellingham, Wash.: WWSC Bulletin, 1960), pp. 23-24.

[8]J. P. Guilford, "A Psychometric Approach to Creativity," Creativity in Childhood and Adolescence, ed. H. H. Anderson (Palo Alto, Calif.: Science and Behavior Books, Inc., 1965), p. 7.

who have been recognized as "creative" individuals are the ones who more fully developed their potential for creative behavior. In this sense, the whole of humanity can be regarded as positioned on a continuum of creativity. Different individuals are at different positions on the continuum depending upon the development of their potential ability or abilities for creative actions.

INTELLIGENCE AND CREATIVITY

For all practical purposes, creative individuals were too long generally regarded as highly intelligent. The term "gifted child" was synonymous with the expression, "child with a high I.Q." Some attempts to separate giftedness or creativity from I.Q. as measured by the intelligence tests were made before factor analysis of intellectual abilities was started. Paul Witty said, in 1940, that

> . . . if by gifted children we mean those youngsters who give promise of creativity of a high order, it appears that the typical intelligence test is unsuitable for use in identifying them for creativity posits originality, and originality implies successful management, control, and organization of new materials or experiences.[9]

Instead of measuring I.Q. of children and identifying "creative" children as those with high scores on these tests, Ann Roe used a different approach. She studied 60 eminent American scientists in different fields. The results showed that they varied considerably in intelligence. What they had in common was an intense driving interest in their chosen fields of science. They had become America's most

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[9]Paul Witty, "Some Considerations in the Education of Gifted Children," Educational Administration and Supervision, Vol. 26 (October, 1940), pp. 512-21.

eminent scientists despite the fact that they would not all make the very highest scores on an intelligence test.[10]

MacKinnon, making a similar study on creative architects, found out that the correlation between I.Q. and degree of creativity was .08. He stated about this finding:

> Certainly this does not mean that over the whole range of creative endeavor there is no correlation between intelligence and creativity. . . . Rather it suggests that a certain amount of intelligence is required for creativity, but beyond that point being more intelligent or less intelligent is not critically determinative of the level of an architect's creativeness.[11]

Getzels and Jackson tested highly creative and highly intelligent children and found that they differ from each other considerably.[12] Torrance confirmed such findings and reported that no matter what measure of I.Q. is chosen, we would exclude about 70 percent of our most creative children if I.Q. alone were used in identifying giftedness.

Fuqua studied the relationship of I.Q. and creative abilities and found some of his results in accordance with Torrance and Getzels and Jackson. He found that creativity and I.Q. tend to correlate only up to about I.Q. 120. Above this, higher I.Q. does not necessarily

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[10] Dael Wolfe, "Intellectual Resources," Scientific American, Vol. 185 (September, 1951), pp. 42-46.

[11] D. W. MacKinnon, "Creativity in Architects," The Creative Person (University of California, Berkeley: Institute of Personality Assessment Research, 1961), pp. 5-12.

[12] J. W. Getzels and P. W. Jackson, Creativity and Intelligence: Explorations with Gifted Students (New York: John Wiley and Sons, 1962), pp. 1-117.

imply higher creativeness.[13]

CAN CREATIVITY BE INCREASED?

The question, "Can you teach for creativity?" has been looked upon differently by philosophers in the past. Analyzing historically, Ralph J. Hallman described three theories regarding creativity which have originated from Plato's writings and have been endorsed completely or with modifications over the past hundreds of years.[14] These theories regarded a creative act as an act of a god, a madman, or a genius. A god can account for originality in creativeness. Madness could account for the irrational and indescribable elements in creative seizure, and genius seems necessary in order to account for the extraordinary visions and sensitivities which the products of the creative person embody. The creative individual, according to these views, is not teachable because in creative moments he is, in fact, not human. It is not his human nature which is engaged in the creative activity.

Hallman further explains his thesis that creative abilities are to be interpreted as natural, as normal, as common to all mankind, and therefore as modifiable by environmental conditions. Creativity equates with the self-actualizing tendencies of the psychologically healthy person. Creativity reflects personality growth, and as such

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[13]E. Paul Torrance, "Explorations in Creative Thinking in the Early School Years," Scientific Creativity: Its Recognition and Development, eds. C. W. Taylor and F. Barron (New York: John Wiley, 1963), p. 183.

[14]Ralph J. Hallman, "Can Creativity Be Taught?" Educational Theory, Vol. 14 (January, 1964), p. 16.

it is subject to the molding influences of education.[15]

A fully functioning person, according to Rogers, is a creative person. With his sensitive openness to his world, and his trust of his own ability to form new relationships with his environment, he is the type of person from whom creative products and creative living emerge.[16]

Based on the premise that creativity is a sign of a healthy, normal personality, researchers have recently undertaken numerous empirical studies for the teaching of creativity. McCormack in his study on college students concluded that creativity training techniques, such as "Brainstorming," "Inquiry Development Sessions," "Morphological Analysis of Problems," and "Invitations to Creative Thinking," were found enormously useful in increasing their scores on creativity tests.[17] Training in problem-solving significantly improved the performance on tests of originality.[18]

In an extensive project at the Creative Education Foundation, University of Buffalo, Sidney J. Parnes and several other research workers conducted a four-year-long study to evaluate creative

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[15]Ibid., pp. 19-20.

[16]Carl R. Rogers, "Toward Becoming a Fully Functioning Person," Perceiving, Behaving, Becoming, 1962 Yearbook of the Association of Supervision and Curriculum Development (Washington, D.C.: NEA, 1962), p. 32.

[17]Alan J. McCormack, "Effects of Selected Teaching Methods on Creative Thinking, Self-Evaluation, and Achievement of Students Enrolled in an Elementary Science Education Methods Course," Science Education, Vol. 55 (3, 1971), pp. 301-7.

[18]I. Moltzman, "Experimental Studies in the Training of Originality," Psychological Review, Vol. 67 (July, 1960), pp. 229-42.

problem-solving courses based primarily on brain-storming.[19] The findings suggest that creative imagination can be deliberately developed. Creative problem-solving courses can measurably improve the ability of students of average intelligence to produce good ideas, the criteria of quality being uniqueness and usefulness. Older students in the age bracket of 23 to 51 gained as much from the treatment as the younger ones between 17 to 22 years of age.

In the elementary schools, Torrance reported that trained second and third graders scored consistently higher on measures of fluency, flexibility, and "cleverness" than did the untrained children.[20] However, the first graders who were also trained during the study did not show growth signs on these criteria.

Shiveley, Feldhusen, Treffinger, and Asher found out in fifth grades that instructions in creative teaching were effective for the divergent thinking functions of verbal and non-verbal originality and for non-verbal fluency and flexibility.[21]

PROBLEM SOLVING AND CREATIVITY

Some confusion surrounds these two terms in the literature. Creative actions are unique and all kinds of problem-solving actions

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[19] Sidney J. Parnes, "Can Creativity Be Increased," A Source Book for Creative Thinking, eds. S. J. Parnes and H. F. Harding (New York: Charles Scribner's Sons, 1962), pp. 185-91.

[20] E. Paul Torrance, "Priming Creative Thinking in the Primary Grades," Elementary School Journal, Vol. 62 (October, 1961), pp. 34-41.

[21] Joe E. Shiveley, John Feldhusen, Donald Treffinger, and J. William Asher, "Effects of Creativity Training Programs and Teacher Influence on Pupils' Creative Thinking Abilities and Related Attitudes," ERIC Microfich Catalogue No. ED047332.

which follow the steps of problem-solving cannot be regarded as creative behaviors. Based on this argument, objections have been levied against Torrance's definition of creativity resembling problem-solving steps. However, Newell, Shaw, and Simon state that problem-solving may be called creative to the extent that one or more of the following conditions are satisfied:

> 1. The product of the thinking has novelty and value (either for the thinker or for his culture).
>
> 2. The thinking is unconventional, in a sense that it requires modification or rejection of previously accepted ideas.
>
> 3. The thinking requires high motivation and persistence, taking place either over a considerable span of time (continuous or intermittently) or at high intensity.
>
> 4. The problem as initially posed was vague and undefined, so that part of the task was to formulate the problem itself.[22]

Guilford stated that creative thinking and problem-solving are essentially the same mental phenomenon.[23] In problem-solving the individual faces a problem for which he does not have a readily available strategy. If he solves the problem employing a strategy he has not used before or a known strategy he has not used in the same way before, he has shown some novel behavior. In this way, the problem-solving can be regarded as comparable to creativity.

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[22]Allen Newell, J. C. Shaw, and Herbert A. Simon, "The Processes of Creative Thinking," Contemporary Approaches to Creative Thinking, eds. Howard A. Gruber, et al. (New York: The Atherton Press, 1962), pp. 65-66.

[23]J. P. Guilford, "Creative Thinking and Problem-Solving," The Education Digest, Vol. 29 (April, 1964), pp. 29-31.

ENVIRONMENT FOR CREATIVITY

The need for developing creative individuals has never been disputed in the history of mankind. It is the creative ideas that have uplifted man from the "caveman" to the modern life style with a tremendous power to use nature for the advantages. Surprisingly enough, there is more agreement among educators on different steps and methods for nurturing creative development than for some other aspects of creativity.

Raina and Raina expressed their belief for protecting and nourishing man's great "human asset." They concluded that

> . . . creativity and spontaneity cannot be directly produced and externally injected into an organism. But there is the possibility of creating a favorable sociological, psychological and educational climate in and outside the school in which creativity, originality and spontaneity will blossom.[24]

Taylor's view is that creative individuals are consistently busy producing "off beat" ideas. Such people need a certain climate for creation. Unless such creative abilities are encouraged, these people are stifled.[25]

Gardner believes that a creative person does not make a conscious effort to create new things. On the contrary, original ideas are developed in a very normal way of life. The creative process is

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[24]T. N. Raina and M. K. Raina, "Perception of Teacher-Educators in India About the Ideal Pupil," The Journal of Educational Research, Vol. 64 (March, 1971), pp. 303-6.

[25]C. W. Taylor, Lloyd Beverley, and Judy Rollins, "Developing Multiple Talents in the Classroom Through the Implementation of Research," Journal of Research and Development in Education, Vol. 4 (Spring, 1971), p. 48.

often not responsible to conscious efforts to initiate or control it. It does not proceed methodically or in a programmatic fashion. It meanders. It is unpredictable, digressive, and capricious.[26]

Researches have revealed the fact that creative students in the classroom often face an unfriendly attitude and environment. Torrance reported that creative students face a very potential sense of disapproval from peers.[27] Buhl reported from his studies on creative engineering students that they want to be only average students, for excelling in their fields will alienate them from close personal relationships with others.[28] Getzels and Jackson concluded that teachers in the classroom do not prefer highly creative students, characteristic of whom is divergency of thought as compared to those with high I.Q. scores on intelligence tests.[29] In the light of these studies it seems inconceivable that children in classrooms will produce their best divergent ideas in a non-receptive environment.

Stressing the need of a suitable environment in schools, MacKinnon states:

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[26]John W. Gardner, Self-Renewal (New York: Harper and Row, 1971), p. 41.

[27]E. Paul Torrance, "Peer Sanctions Against Highly Creative Children," Education and the Creative Potential, comp. E. Paul Torrance (Minneapolis: The University of Minnesota Press, 1967), pp. 119-36.

[28]H. R. Buhl, Understanding the Creative Engineer (New York: American Society of Mechanical Engineers, 1961), pp. 1-20.

[29]J. W. Getzels and P. W. Jackson, "The Highly Intelligent and the Highly Creative Adolescent: A Summary of Some Research Findings," Scientific Creativity: Its Recognition and Development, ed. Calvin W. Taylor and Frank Barron (New York: John Wiley & Sons, Inc., 1963), pp. 161-72.

> Our task as educators is not to recognize creative talent after it has come to expression, but, either through our insight or through the use of validated predictors, to discover talent when it is still a potential and to provide the kind of educational climate and environment that will facilitate development and expression.[30]

Considering that a receptive or "responsive environment" is preferred for nurturing creative abilities of children, Torrance made a clarification about what it is and what it does not entail. He states:

> What I mean by a responsive environment is quite different from laissez-faire and permissiveness. What I have in mind calls for the most alert and sensitive kind of direction and guidance. It means building an atmosphere of receptive listening, relieving the fears of the overtaught and overguided, fending off devastating disparagement and criticism, stirring the sluggish and deepening the superficial, making sure that every sincere effort brings enough satisfaction to assure continued effort, heightening sensory awareness, and keeping alive the zest for learning and thinking.[31]

Rogers describes the conditions for fostering creativity as "psychological safety" and "psychological freedom." He claimed that three processes are associated with providing psychological safety to individuals in the classroom or outside. First, "accepting the individual as of unconditional worth," implying that the facilitator has unconditional faith in the individual no matter what his present state. Second, "providing a climate in which external evaluation is absent." Third, "understanding emphatically," which means "accepting" an

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[30]Donald W. MacKinnon, "What Do We Mean by Talent and How Do We Test for it," The Search for Talent: Handbook (New York: College Entrance Examination Board, 1959), pp. 20-29.

[31]E. Paul Torrance, "Toward the More Humane Education of Gifted Children," Creativity: Its Educational Implications, eds. John Curtis Gowan, et al. (New York: John Wiley & Sons, Inc., 1967), pp. 53-70.

individual after understanding his feelings and his point of view and approving of his actions.

The "permissiveness" or "psychological freedom" considered by Rogers is the permission to be free with responsibility. He states that permissiveness

> . . . is not softness or indulgence or encouragement. . . . The individual is as free to be afraid of a new venture as to be eager for it; free to hear the consequences of his mistakes as well as of his achievements. It is this type of freedom responsibly to be oneself which fosters the development of a secure locus of evaluation within oneself, and hence tends to bring about the inner conditions of constructive creativity.[32]

The following quotation from Perceiving, Behaving, Becoming, clarifies the position that the school as a whole has to realize the objective of producing creative individuals. The doubts about conformity and creativity are emphatically absolved for teachers, administrators and society collectively:

> Schools may have conforming pupils or creative ones, but whichever choice is made, teachers, parents, administrators, all of us, need to be prepared to pay the price. For conformity and creativity are essentially antithetical -- what produces one tends to destroy the other. Conformity calls for restriction, order, direction, control; creativity for freedom, experimentation, expression and facilitation. Teachers who want creativity can count on it -- their classrooms will not be neat, quiet and orderly. Administrators who demand rigid conformity can count on it -- their students will not be very creative, except possibly in devising ways to circumvent controls. The public, demanding more genius and creativity, on the one hand, and more rigid control, less "frills" and less expense, on the other, must also face the fact it cannot have both simultaneously. . . . A choice has to be made either for institutional order and dogmatism or for flexibility and

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[32]Carl R. Rogers, "Toward a Theory of Creativity," A Source-book for Creative Thinking, eds. Sidney J. Parnes and H. F. Harding (New York: Charles Scribner's Sons, 1962), pp. 63-72.

freedom. Both conformity and creativity cannot grow in the same school atmosphere or classroom climate.[33]

With the change in roles from authority to participant, the teacher has to still recognize the fact that it takes planned classroom procedures to nurture creative talent.

TEACHER'S ROLE IN PROMOTING CREATIVITY

The teacher occupies a very important position in the education process of children. It is generally assumed that most of her actions, views, and style of teaching will have a direct bearing on what children accomplish. In this promotion of creativity her position is, perhaps, even more significant since it requires a certain environment in the classroom.

"Divergency of thinking," being a natural process for children in the classroom, when encouraged can modify the children's output in terms of originality and uniqueness with slight changes in style and approach.[34] The programs to promote creativity should become part of the whole school and the education process. "Opportunities for creative expression are not adequately supplied by adding a half-hour here for drawing and another there for 'creative' music or rhythms."[35]

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[33]"Creativity and Openness to Experience," Perceiving, Behaving, Becoming, 1962 Yearbook, Association of Supervision and Curriculum Development (Washington, D.C.: NEA, 1962), pp. 141-63.

[34]P. R. Christensen, J. P. Guilford and R. C. Wilson, "Relations of Creative Responses to Working Time and Instructions," Journal of Experimental Psychology, Vol. 53 (Feb., 1957), pp. 82-88.

[35]J. A. Hockett, "The Significance of Creative Expression," California Journal of Elementary Education, Vol. 9:163, 1941.

Torrance after extensive research and experience with children in classrooms suggested the following five steps for teachers to promote creativity:

1. Be respectful of unusual questions.
2. Be respectful of imaginative, unusual ideas.
3. Show your pupils that their ideas have value.
4. Occasionally have pupils do something "for practice" without the threat of evaluation.
5. Tie in evaluation with causes and consequences.[36]

Gaier and Dellas gave a practical suggestion to practicing teachers for resolving conflicts which creative children face in a classroom. When the child acts or thinks in a manner at variance with the teacher's expectations, instead of saying, "Something is wrong with him," or "He is asking the wrong questions," teachers and laboratory researchers ought to ask themselves, "Is there something wrong with my assumptions and interpretations of this child's behavior?"[37]

Guilford believed that most training should be general rather than specific in classrooms.[38] The emphasis should be laid on the general aspects of information to be learned. Strategies should be learned that have general application in connection with new information.

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[36]E. Paul Torrance, Rewarding Creative Thinking (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965), p. 46.

[37]Eugene L. Gaier and Marie Dellas, "Concept Formation and Creativity in Children," TIP (Ohio State University, Vol. 10 (April, 1971), pp. 117-23.

[38]J. P. Guilford, "Basic Problems in Teaching for Creativity," Instructional Media and Creativity, eds. Calvin W. Taylor and Frank Williams (New York: John Wiley & Sons, Inc., 1966), p. 74.

Gallagher has listed several changes suggested by concerned teachers for creating a creative instructional environment. He states:

1. Organize and base the curriculum primarily on the teaching of concepts, rather than of facts.

2. Allow more individual assignments of projects under competent supervision.

3. Bring the students into contact with the maximum talent and knowledge available in the teaching staff.

4. Follow the general philosophy that "Truth is something to be sought for, rather than something that will be revealed."

5. Provide more competence in content and pedagogy in teacher training.[39]

Making use of Torrance's results,[40] Hallman suggested that children should be provided opportunities to manipulate materials, ideas, concepts, tools, and structures in the classroom. Two of the other ideas included by Hallman are to enable children to cope with frustration and failure, and to urge pupils to consider problems as wholes.[41]

Raina and Swami considered "investigatory projects" as prominent classroom activities for promoting creativity.[42] The teacher's role in the classroom changes significantly for the development of

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[39]James J. Gallagher, Teaching the Gifted Child (Boston: Allyn and Bacon, 1964), pp. 193-96.

[40]E. Paul Torrance, "The Role of Manipulation in Creative Thinking," Education and the Creative Potential, comp. E. Paul Torrance (Minneapolis: The University of Minnesota Press, 1967), pp. 111-18.

[41]Ralph S. Hallman, "Techniques of Creative Teaching," Journal of Creative Behavior, Vol. 1 (Summer, 1967), pp. 325-30.

[42]M. K. Raina and Piyush Swami, "Developing Creativity Through Investigatory Projects," Teaching (September, 1969), pp. 2-8.

creative talents. She becomes a listener and participant rather than a leader. In most creative classrooms, teachers, perhaps, learn as much as the students. The teacher does not pass on instructions to follow, but observes things happening in several directions -- conventional and non-conventional ways.

Teachers develop respect for students' personalities by supporting different ideas from their own. Mistakes are accepted as normal activities and considered significant for learning. Making a mistake does not imply failure in learning. A mistake is one's own evaluation or assessment of one's own effort. In a creative classroom, "always the individual who is making the effort must see wherein his plans have gone wrong, else no mistake exists and no learning takes place."[43]

The teacher's role becomes one of a helper and facilitator. She provides opportunities and materials which spark off creativity in children. Margaret Mead considers that "more than protection from active discouragement, much more than rewards and praise, the gifted child needs scope, material on which his imagination can feed, and opportunities to exercise it. He needs inconspicuous access to books, museums, instruments, paints, ideas, a chance to feed himself with the accumulated heritage from the genius of other ages."[44]

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[43]Mary B. Lane, "Let's Give Johnny Freedom to Make Mistakes," Childhood Education, Vol. 39 (April, 1963), pp. 382-83.

[44]Margaret Mead, "The Gifted Child in the American Culture Today," Journal of Teacher Education, Vol. 5 (Sept., 1954), pp. 211-14.

Decision-making responsibilities are transferred to students except in safety procedures. Ojemann believed that if we are interested in the cultivation of creative ability, there is need for less of the arbitrary judgmental approach and for more of an attempt to understand the various forms of behavior which a child may show.[45]

The logical way to intensify divergent thinking in schools is to crumble down the conformity of expectations and desired ends, procedures and materials to be employed. The tremendous stress on finding very specific answers does not leave a wide scope for producing "off beat" ideas. Creativity usually occurs after several frustrating moments and false starts.[46] The open-ended questions which focus a query without describing the right answer or procedure for getting at it are important features for promoting divergent thinking. Selection of content which emphasizes "assimilation" or recall provides little scope for thinking.[47]

Several models have been proposed in the literature for liberating creative potential. Osborn introduced "brain-storming" techniques for promoting divergent ideas in the classroom.[48] Mearns

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[45]Ralph Ojemann, "Developmental Factors Related to Productive Thinking," Productive Thinking in Education, Report by National Education Association (New York: Carnegie Corp., 1968), p. 82.

[46]Norris M. Sanders, Classroom Questions: What Kinds? (New York: Harper and Row, 1968), p. 130.

[47]Hilda Taba, "Opportunity for Creativity in Education for Exceptional Children," Exceptional Children, Vol. 29 (Feb., 1963),

[48]Alex F. Osborn, Applied Imagination: Principles and Procedure of Creative Problem-Solving (New York: Scribners, 1957), p. 417.

stressed the need for positive reinforcement of every original behavior.[49] Another technique, called "synectics," "attempts to amalgamate disparate individual experiences in small groups to arrive at creative solutions through the use of metaphorical mechanisms."[50] "Morphological Analysis of Problems," proposed by Zwicky, utilizes a chart to "force relationships" as a step for developing original solutions to problems.[51] Suchman developed "Inquiry Development" techniques for promoting creative thinking. The students are motivated in this technique by introducing a perplexing discrepant event. It is followed by sessions of question-answering. The teacher's role becomes one of allowing students to gather data freely with his help but not the direction.[52] However, Bills reported that "Inquiry Development" techniques used in eighth grade science classes did not produce more creative students.[53]

The process of creating a divergent thought and action involves the sensing of a problem, hypothesizing, "messing" about with materials. verifying ideas for suitability and retesting if necessary until

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[49]Hughes Mearns, The Education of Youth in the Creative Arts (New York: Dover, 1958), p. 272.

[50]William J. J. Gordon, Synectics: The Development of Creative Capacity (New York: Harper, 1961), pp. 1-180.

[51]Fritz Zwicky, "Morphological Analysis," cited in A Source Book for Creative Thinking, eds. S. J. Parnes and H. F. Harding (New York: Charles Scribner's & Sons, 1962), p. 255.

[52]J. Richard Suchman, "Creative Thinking and Conceptual Growth," Educating the Ablest, eds. J. C. Gowan and E. P. Torrance (Itasca, Illinois: Peacock Publishers, Inc., 1971), p. 95.

[53]Frank Lynn Bills, "Developing Creativity Through Inquiry," Science Education, Vol. 55 (No. 3, 1971), pp. 417-21.

the experiment is effective. A creative action is strongly problem-centered. The success of "thinking" ability depends upon the degree of appropriateness of solutions The permission to suggest all the possible, spontaneous or non-spontaneous answers, as in "brain-storming" sessions, should perhaps liberate the intellect from converged ways of thinking. But the wild ideas for solutions to the problem are valid only when these complete the repeated tests for suitable answers to the problem under study. It seems a paradox if the judgments regarding the appropriateness of suggested solutions are delayed for longer periods of time. The creative process is a comprehensive process, therefore it is safe to assume that the model to facilitate such actions in schools should also cover all aspects of intellectual contributions.[54]

Lesser comprehensive programs "like brainstorming . . . may stimulate divergent thinking and surface originality, but can hardly contribute adequately to the development of creativity. . . . The enrichment programs seem to be addressed more to rapid learning than to creativity."[55]

The problem-solving model suggested by Guilford consists of a sequence of events set of operations and their interaction with memory storage.[56] "The Productive Thinking Program" is another model which

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[54]J. P. Guilford, "Basic Problems in Teaching for Creativity," Instructional Media and Creativity, eds. Calvin W. Taylor and Frank Williams (New York: John Wiley & Sons, Inc., 1966), pp. 71-103.

[55]Hilda Taba, op. cit., p. 254.

[56]J. P. Guilford, op. cit., pp. 79-84.

attempts to sensitize children for different cognitive styles and attitudes in the problem-solving process.[57]

In order to solve a problem, the individual ought to have some abilities or "intellectual skills." It is these "intellectual skills" which are called "processes" by Williams,[58] "intellectual habits" by Bruner,[59] "operations" by Guilford,[60] and "logical operations" by Piaget.[61] Psychologists have believed that a child is unable to solve a problem before certain mental operations can be carried out successfully. These abilities provide a framework for strategic behavioral capabilities for the individual to deal with problems effectively.[62] For example, a child is not likely to classify objects in different categories unless he can see similarities and differences in various objects on which to base a single-stage classification.

The justification for the emphasis on process education as compared to content- or knowledge-based education has been discussed

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[57] M. V. Covington, R. D. Crutchfield and L. P. Davis, Teacher's Guide to the Productive Thinking Program (Berkeley: University of California, 1967), pp. 1-18.

[58] F. E. Williams (ed.), Creativity at Home and in School (St. Paul, Minnesota: Macalester Creativity Project, 1968), pp. 27-41.

[59] J. S. Bruner, Toward a Theory of Instruction (New York: Norton and Co., Inc., 1967), pp. 1-89.

[60] J. P. Guilford, The Nature of Human Intelligence (New York: McGraw Hill, 1967), p. 62.

[61] Jean Piaget, Six Psychological Studies (New York: Random House, 1967), pp. 1-164.

[62] From the Presidential Address by R. M. Gagne ("Learning Hierarchies") to The American Psychological Association at San Francisco, August 1968.

widely in the literature. These arguments are based on one common belief, that with 10 years as a doubling period for knowledge, it is virtually impossible to impart education for knowledge alone. If such education is pursued, it will be soon that the individual's ideas become outdated.

A second common idea expressed by educationists is the vastness of knowledge. The store of knowledge is "so vast that it is impossible to instruct the student in anything but a small portion of what is known."[63] The only option left with educationists is to provide some central information and to train an individual in those "skills" which "will enable him to adapt and expand his limited knowledge acquired in his formal schooling."[64]

SCIENCE AND CREATIVITY

The basic core of the creative process is the ability to create new knowledge with or without the direct help of previous knowledge. In this sense, process-based education, which provides individuals with the essential abilities for creating knowledge in the future, should become synonymous with the creativity facilitation programs.[65]

Elementary Science Study (ESS) materials are characterized by their flexibility, promotion of independent thinking, and freedom for

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[63]B. S. Bloom (ed.), Taxonomy of Educational Objectives, Handbook I: Cognitive Domain (New York: David McKay Company, Inc., 1956), pp. 1-140.

[64]Henry P. Cole, "Process Curricula and Creativity Development," Journal of Creative Behavior, Vol. 3 (Fall, 1969), pp. 243-59.

[65]Ibid., pp. 251-52.

trying out one's own ideas. The ESS units do not put the stress on process learning deliberately as some other curriculum materials have tried,[66] but attempt to make it so natural for children that they do not even realize that they are acquiring these abilities. In a classroom, ESS puts physical materials into children's hands from the start and helps each child investigate through these materials the nature of the world around him. The processes are learned while the child explores these materials by himself or with others.

ESS materials are based on the notion that "children are scientists by disposition: they ask questions and use their senses as well as their reasoning powers to explore their physical environments. . . . It is this natural curiosity of children and their freedom from preconceptions of difficulty that ESS tries to cultivate and direct into deeper channels."[67] The children are involved in the process of exploration with no pressure on them to do things faster. This allows them to develop processes with better understanding and with more thoroughness.

ESS units help children to learn how to "put things together," "make things happen," "find out what things are," "count," "build," and "reason." Hawkins believed that "messing about" with materials when children are allowed to construct, test, probe, and experiment without

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[66] Science: A Process Approach, curriculum material developed by the American Association for Advancement of Science.

[67] Introduction to the Elementary Science Study (Newton, Mass.: Education Development Center, 1966), p. 1.

superimposed questions or instructions, "carries over into school that which is the course of what children have already learned. It becomes a way of working that is no longer childish, though it remains always childlike, the kind of self-disciplined probing and exploring that is the essence of creativity."[68]

On the one hand, creativity is comparable to problem-solving and process-oriented teaching; on the other hand, effective science instruction, in general, and ESS materials in particular, provide diverse and wide opportunities for learning the processes. It is logical to assume from this that if process-oriented science instruction is carried out effectively, creative abilities of children will find channels for expression and development.

An effective science program, which can be useful for creativity development, emphasizes several processes. Starting from observation, it leads to classification, question asking, hypothesizing, experimentation, interpretation, and communicating the results. Piaget's description of the child's intellectual development reveals that most children connected with this study (eight or nine years of age) are in the concrete operations stage. The children during this stage generally are capable of thinking about concrete objects rather than abstract objects.[69] The children develop abilities for performing elementary logical operations and make elementary groupings of

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[68]David Hawkins, "Messing About in Science," The ESS Reader (Newton, Mass.: Education Development Center, 1970), pp. 37-44.

[69]Ronald D. Anderson and others, Developing Children's Thinking Through Science (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970), pp. 113-40.

classes and relations. Among the processes listed above, perhaps observation and classification are two processes which children develop extensively during this age group. Based on the argument developed before, it can be suggested that an increase in these two abilities may show a substantial growth in the creativeness of children.

Piaget's researches concluded that observation of objects beyond merely a reflex response starts in a child towards the end of the fourth week after birth. The stage surmounted during the fourth week is extremely significant. The child begins "really to look, instead of contemplating vaguely," and the face assumes "a definitely intelligent expression."[70] The child stops crying in order to look before him for long minutes in succession without even making sucking-like movements.

Inhendler and Piaget in their intensive study of the origin of classification abilities showed that these abilities are shown by children in the sensory-motor stage. Between the ages of six and eight and 18 to 24 months, we find a number of behavior patterns which are suggestive both of classification and of seriation. A child may be given a familiar object, immediately he recognizes its possible uses, the object is assimilated to the habitual schemata of rocking, shaking, striking, throwing to the ground, and so on. A sort of practical classification is evident in the behavior of children.[71] This is just

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[70]Jean Piaget, The Origins of Intelligence in Children (New York, N.Y.: International University Press, Inc., 1952), p. 63.

[71]Barbel Inhelder and Jean Piaget, The Early Growth of Logic in the Child (London: Routledge and Kegan Paul, 1964), p. 13.

the origin of classification behavior. More experiences with people, objects and language help to develop this latent talent.

The mastery of major "operations" of classification is carried out in the concrete-operational stage. Eight kinds of relationships are learned during this period. These are the hierarchy of classes (based on the relation of members to each other), order of succession, substitution, symmetrical relations, multiplication of classes, multiplication of series, family tree, and family tree of classes.[72]

Inhendler and Piaget developed a sequence of 11 partially ordered steps. They contended that the child starts classification behavior from resemblance sorting and then goes through logical links in order of consistent sorting, exhaustive sorting, conservation, multiple class membership, horizontal classification and hierarchical classification. Some probabilistic links representing relations such as "Some" and "All," A + A = B, B - A = A and B > A continue simultaneously after they start recognizing that objects can belong to more than one class.

Kofsky reported that the observed order of task difficulty of classification concepts was in accord with theoretical expectations. But she reported that the sequence for the mastery of these earlier stages to achieve the mastery over higher sequences of classification was not in the same order. Some of the more advanced tasks were

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[72]Ruth M. Beard, An Outline of Piaget's Developmental Psychology for Students and Teachers (New York: Basic Books, Inc., 1969), p. 27.

accomplished before satisfying minimum standards of easier tasks.[73]

The role played by language in the development of classification abilities is obvious. All nouns and adjectives divide reality into classes. Insofar as children use words with the same meaning as adults, these may be directly transmitted to them when they learn to talk.[74] However, studies of deaf children showed that they carry out the same elementary classifications as do normal children, but are retarded in their handling of more complex classifications (e.g., changing from one criterion to another using the same elements). In other words, deaf children undoubtedly show signs of operational thinking, as we understand the term; and this may be due to the fact that they use symbols (e.g., sign language). So it looks as if the social transmission of spoken language is not essential for the formation of operational structures. But it certainly helps, and it may well be necessary although not a sufficient condition for the completion of these structures in their generalized forms.[75]

To the author's knowledge, the number of researches which have tried to combine science instruction with the development of creativity in elementary schools is rather small. Lehman reported that the total number of questions asked by junior high school students

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[73]Ellin Kofsky, "A Scalogram Study of Classificatory Development," Logical Thinking in Children: Research Based on Piaget's Theory, eds. Irving E. Sigel and Frank H. Hooper (New York: Holt, Rinehart and Winston, Inc., 1968), pp. 210-24.

[74]Barbel Inhelder and Jean Piaget, op. cit., p. 2.

[75]Ibid., p. 3.

in science classrooms is more affected by creativity than by intelligence.[76]

In another study, conducted by Ransom, Science--A Process Approach based instruction was carried out in second grade classrooms. After the treatment was over, no difference was found among the groups' performance on the tests of creativity. However, significant correlations were reported in pupils' scores on the process measures and certain sub-scores on the Torrance Tests of Creative Thinking (Figural).[77]

The thrust of research in science education has been towards examining the effectiveness of new curricula for different levels, teacher preparation, evaluation procedures and instructional techniques. ESS materials have not been explored by many researchers in the past for their role in promoting creativity.

SUMMARY

To summarize, creativity can be identified as a process of thinking in divergent ways. Most individuals possess creative talent. The highly intelligent individual, as measured by intelligence tests, is not necessarily highly creative. However, there is evidence that

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[76]Robert A. Lehman, "The Effects of Creativity and Intelligence on Pupils' Questions in Science," Science Education, Vol. 56, No. 1 (January-March, 1972), pp. 103-21.

[77]Wayne E. Ransom, "Effect of Science--A Process Approach on Creative Thinking and Performance in Selected Processes of Science in the Second Grade," doctoral dissertation, Syracuse University, cited in James T. Gallagher, "A Summary of Research in Science Education for the Years 1968-69, Elementary School Level," Journal of Research in Science Teaching (New York: John Wiley, 1972), Vol. 9, No. 1, pp. 21-22.

the potential talent of individuals can be developed through educational experiences structured in and outside school.

Creativity is a normal trait of individuals as against notions such as madness, divine acts or genius attached to the term. The training in elementary schools through colleges which has been seen to be useful for the development of creativity requires certain conditions. The major condition is the receptive and responsive environment in the school. Creative individuals tend to "hold back" in their abilities in the contrary environment of authority and conformity.

The teacher should allow initiative on the part of students. He becomes a helper rather than an instructor as the term is known.

The process-oriented education develops certain intellectual traits which seem to be helpful for better and more divergent thinking. There seems to be a logical connection between science teaching which is process-oriented and the enhancement of creative talent.

Psychologists have shown that children grasp certain processes at a particular age level. The third graders, eight to nine years of age, who are the subjects of this study, generally are capable of grasping the concepts of observation and classification.

Chapter 3

PROCEDURE

Relating the effectiveness of Elementary Science Study materials for the development of creativity, the following hypotheses were proposed for verification in this study:

1. The children subjected to instruction in Elementary Science Study (ESS) materials will show higher scores on the verbal form of Torrance Tests of Creative Thinking than those who do not have such instruction.

2. The children subjected to instruction in Elementary Science Study (ESS) materials will receive higher scores on the figural form of Torrance Tests of Creative Thinking than others who do not have instruction in Elementary Science Study materials.

3. The children who have had instruction in Elementary Science Study (ESS) materials will show higher fluency and flexibility on the test of Observation and Classification than those who do not receive instruction in Elementary Science Study materials.

SUBJECTS AND SETTING

The study was conducted in the District 501 schools of Bellingham, Washington. From the convenience point of view for conducting the study, this was the best city. The college faculty was readily available for consultations in Bellingham. Besides, the investigator was

more aware of the Bellingham school system than any other system in the United States.

Bellingham, Washington is a city with approximately 40,000 people. It is the county seat of Whatcom County adjacent to the Province of British Columbia in Canada, just across the international border. Bellingham includes a large white population, relatively smaller populations of American Indians, Blacks, migrant workers, and foreign citizens. Besides three major industrial operations in the city and its vicinity, there is a large population connected with the local college. Most other people are attached to small businesses. The families, in general, belong to both a middle and lower economic status. At the third grade level, which was selected for the study, there are only four private schools functioning in the town in addition to a number of public schools. None of the private schools was used in the study.

The Bellingham Public Schools system operates 15 elementary schools with individual school populations varying from 100 to approximately 400 children. Generally, it appeared that the schools of the district utilize quite uniform facilities and express the same educational philosophy. After the study was finished, however, a new building, based on the open classroom philosophy, was added to replace an old school. Student teachers and micro-teachers from the local college are distributed in practically all the schools in the city. No public school is singled out for the children from a particular socioeconomic group. Children are not bussed to achieve racial balance.

A sample of two schools was drawn from nine schools which had

two third grade classrooms in the same building, a condition for the study described later in the chapter. The schools were selected for the study on the basis of convenience and the willingness of the administration and personnel involved. The two selected schools had student populations of 348 and 381 at the end of the year. The four third grade classrooms in two buildings in two different parts of the city were typical in size -- 17 to 23 children in a class at any one time. All these classrooms were self-contained classrooms taught by a single teacher.

PROCEDURE FOR SOLICITING SCHOOL DISTRICT SUPPORT

An upswing of experimental and quasi-experimental studies carried out in the schools has caused the school district's administrators to view critically the merits and demerits of such research. Administrators feel their concern is based on their interest in the child. A researcher wants an unconditional and full cooperative effort from the administration of the school district. The administration, on the other hand, properly considers its responsibility to be primarily towards children and the public at large. The administration prefers a cautious approach which may mean, at times, a refusal to researchers to use children in the exploration of new ideas. Since both the administration and the researcher have a common objective to help children, it is the conviction of the investigator that pseudo-conflicts may be eliminated to a great extent through improved communication. Furthermore, in a personal communication, LeVon Balzer reported, after surveying hundreds of classroom researches, that extremely few researchers

have described their processes of "selling" the benefits of their research to school administrations.[1] There seems to be a need for firm guidelines to help relatively inexperienced researchers to seek support from school districts.

For the purpose of this study, first of all, a thorough discussion of the procedure and the requirements of the study was carried out among the college faculty members and the investigator. An overview of the study was prepared, emphasizing the specific needs from the schools and the rationale behind them. A formal meeting was then arranged between the school administration and the college faculty with the investigator to explore possibilities of conducting this study in local schools. A general plan of the study was discussed in the meeting. The advantages of the study for the administration, teachers and children were stressed. The written research proposal was left with the administration for further study. A follow-up letter outlining the agreements of the meeting and specific requirements was sent to the administration. This letter is presented in Appendix A. The administration became concerned about curricular changes resulting from the study and the support from the college. In the succeeding personal meetings and telephone conversations the Science Education Center at the college, faculty members and the investigator clarified such doubts.

After clarification of the above concerns, the administration showed its willingness to proceed with the study. The investigator

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[1]Statement by LeVon Balzer, personal interview, December 15, 1971.

then worked with the science curriculum committee which was composed of principals and teachers from the district's schools. A significant observation was made, in working with the curriculum committee, which has several implications. It was suggested by this committee that the investigator and his associates should explain the study to the entire group of teachers in the district to explore their interest for participation in it. Because of certain demands of the design of this study, and to save time, a different procedure was suggested by the investigator. The investigator made personal contacts in individual schools contemplated for the study which had two third grade classes. These contacts and their results were endorsed by the officials. The curriculum committee, together with the investigator, decided on the particular schools and teachers available for the experiment.

Our experience indicates that teachers, in general, are more cooperative and willing to indicate their interest in working with new ideas when they are approached individually. Perhaps, for bigger studies it may be useful to conduct meetings with large groups of teachers and solicit their collective support. But for relatively small studies such as this, we prefer individual contacts over other methods.

This conclusion is based on two judgments. The first is that every speaker is not a charismatic speaker and successful in instilling motivation and excitement among teachers in a large group. The second is that through individual contacts the investigator gets a much better idea about the philosophy, views and personality of possible prospective teacher participants in the study. However, much of

the success of individual contacts depends on how the communications are established with teachers. Convincing a teacher from a position of authority usually creates antagonistic feelings in teachers. But the image of a true experimenter who is interested in testing hypotheses without any real superiority complex creates good will among teachers.

In all, four teachers were approached individually by the investigator. All of them agreed to participate in the study. The two schools selected were considered as typical schools of the area. In most measures of children, facilities, teachers and the instructional program, these schools were similar to other public schools in the city. All the four third grade teachers in these two schools were selected to participate in the study.

ORIENTATION OF TEACHERS

In each of the two buildings, one third grade classroom was used as a control and the other as an experimental group. The children in the experimental classrooms were provided instructions in Elementary Science Study (ESS) materials. The children in control classrooms were given instructions in the usual manner without the introduction of ESS materials.

For the orientation purposes, the meetings were organized individually with the teachers. The two teachers whose classrooms were to be used as the control were given a general layout of the study without mentioning the word "creativity" or implying some kind of "competition" between their classrooms and the experimental classrooms.

Beginning with the initial meetings with the two teachers of the experimental classrooms, an attempt was made to convey the concept and philosophy of Elementary Science Study (ESS) materials. Brief articles and brochures were provided to the teachers for future reference and detailed study of ESS materials.[2] After going through the ESS materials individually, the two teachers discussed their doubts about the classroom management, the teacher's role, the time allowed for each unit, and other points with the investigator and the major thesis advisor.

During the orientation of the experimental teachers the emphasis was placed on knowing about ESS materials. No exclusive training in creativity-promoting techniques was included. The particular units to be used in the study were passed on to the teachers, with the teacher's guides and kits, to facilitate understanding and making a detailed study of the materials involved. The two teachers were encouraged to make their own decisions about the time and the frequency of the use of ESS materials. No rigid rules were formulated beforehand for them to follow during the study. Because the teachers had either taught ESS materials or seen student teachers and micro-teachers using these materials in other classrooms, it was felt that it was unnecessary to show a film on classroom operation using ESS. However, suitable pictures were provided with the written materials to explain vital points of the materials.

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[2]One experimental classroom teacher had seen Elementary Science Study materials being taught by micro-teachers in other classrooms before. Therefore, she had some awareness of the materials.

EXPERIMENTAL PROCEDURE

The pre-tests were administered to all the children in the four classrooms except the Verbal Form A of Torrance Tests of Creative Thinking which was administered to randomly selected children from the four classrooms. After this, the two classrooms (one in each building), which were identified as the control, were left under the direction of their teachers for eight weeks. No indication was made to the control teachers or students about the treatment details being carried out in the experimental classrooms. The teachers in the control classrooms continued teaching whatever content and method were used before.

In the experimental classrooms, at least four ESS units were covered by each child in a period of eight weeks. The units which were available for use included: Attributes, Games and Problems; Changes; Clay Boats; Mobiles; Behavior of Mealworms; and Growing Seeds. The regular classroom teachers conducted their classrooms as usual during this period. The kits were provided for each child in the experimental classroom for his use. Additional ideas, modifications in the kit and any other move by the child was allowed. The teachers allotted time for working on these units according to the interest shown by the children. On some days more time was given to these units than others and on a few days no time was given. After a period of eight weeks, a post-test was given to all children except the Verbal Form B of Torrance Tests of Creative Thinking which was administered to randomly selected children from the four classrooms.

It was felt that additional information on methods and

activities used in the control and experimental classrooms might be helpful for the interpretation of data. Therefore, the investigator interviewed one experimental and one control teacher at the end of the eight-week session. Their interviews are included in Appendix F.

PRE- AND POST-TESTS

Each of the pre- and post-tests included three kinds of tests. These were: Torrance Tests of Creative Thinking Figural, Torrance Tests of Creative Thinking Verbal, and the test of Observation and Classification made by the investigator. In the pre-test, Forms A of each of the tests were used. In the post-test, Forms B of the three tests were used. The verbal part of the TTCT was administered to 30 randomly selected children from the four classrooms. Forms A and B of the Verbal test were administered individually to each of the 30 children according to the manuals accompanying the tests. A slight modification was made in the recording procedure, on the approval of the author of the test, E. Paul Torrance, in his letter of October 16, 1971 to the investigator (see Appendix C). A tape recorder was used in the background to record every conversation and compare it to the written responses.

The Figural form of the Torrance Tests of Creative Thinking was administered to three children at a time as approved by E. Paul Torrance. The test administrators were individuals who had worked with children in elementary schools and were acquainted with the concept of creativity as used in the test. The orientation and training of these individuals for administering the test was directed by the

investigator himself. The training lasted over several one- to two-hour-long sessions which attempted to cover all the significant features of the test according to the test manual and related literature on creativity. Brief explanations of the purpose and method of testing were described. The manuals were handed out for self-study. A sheet of instructions to examiners, prepared by the investigator (see Appendix D), was passed out for quick reference. Simulation training was employed for practice.

Before administering the test on the subjects, each administrator observed the investigator administering the test once or twice. Later, the investigator supervised the test administration and was available for help. The test manuals were followed strictly. On each of the three activities the labeling was done by the test administrator (as suggested in the manual), since some of the children in the third grade had writing problems.

The reliability and validity data on both the verbal and figural forms of the Torrance Tests of Creative Thinking have been established for kindergarten through college graduate groups.[3]

The investigator constructed the third test on Observation and Classification. The rationale for stressing considerable emphasis on the abilities of observation and classification has been previously developed in Chapter 2. The test included two activities, stressing one each for observation and classification abilities. The activities

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[3]E. Paul Torrance, "Torrance Tests of Creative Thinking Norms - Technical Manual Research Edition" (Princeton: Personnel Press, Inc., 1966), pp. 17-75.

were developed on the basis of materials used in the standard curriculum materials such as AAAS, SCIS and CHEM study materials. The actual materials used in the activities were familiar to the children.

This test was administered in a group situation -- one classroom at a time. The instructions were given in simple words to make sure that the children understood them clearly. The children were prepared for the test by eliciting examples from them on similar activities before each actual activity started.

For the classification activity, various materials such as paper shapes of circles, squares, triangles of different color and sizes, several kinds of seeds, and metal pieces were provided in paper sacks for each child. The instructions were explicit to make groups of these materials according to any way they wanted and to write them down. An illustrative example of making groups was given on a similar activity (grouping children in the classroom) before handing out the actual paper sacks. Help was provided to children who were unable to verbalize but were able to distribute objects in groups on their desks. The actual materials in the sacks used in the pre- and post-tests were changed.

To test the observation ability, a paraffin wax candle was passed to each child. They were then asked to record all that they saw in the candle before, during and after lighting it. After they stopped recording, everybody blew out his candle. They were again asked to record what they saw. This activity remained the same for both the pre- and post-test. Children were prepared for this activity by eliciting responses from them on "what they saw about the movement of

the administrator when he walked to turn off the lights."

There was no time limit on either Observation and Classification activity. The children were allowed to write as long as they wished. Usually the time used by the children varied from approximately 25 to 40 minutes on these activities in addition to instructions. The atmosphere in the classroom was kept as informal and tension-free as possible. The word "test" was never used for these activities. The detailed description of the test and criteria for scoring fluency and flexibility are discussed in Appendix E. No reliability or validity data are available for the test of Observation and Classification.

ROLE OF THE INVESTIGATOR

Classroom instruction was carried out by the regular teachers in the control and experimental classrooms. The investigator made frequent visits to all the four classrooms. The capacity of the investigator during such visits was strictly that of a social visitor and observer. No instructional directions were provided by him when children approached him with their materials in either the experimental or the control classroom. A brief conference was held with the experimental teachers following such visits and points of significance were discussed. The number of visits in both the control and experimental classroom was kept almost equal. The investigator provided a videotape experience to all the children in both the control and the experimental classrooms. No earlier preparations were made for this. The children were video-taped for what they were doing on particular

days. The experience was not designed to influence the outcome of the study in any way. The kits, teacher's guides, and related materials were borrowed from the Science Education Center at Western Washington State College and made available to the experimental teachers by the investigator.

It cannot be overstated that, although teachers taught the actual material, the investigator was considerably interested and active in knowing precisely how it was taught. His role was not to criticize the teachers' approach but to be available with suggestions and to serve as facilitator to the experimental teachers. The role was that of a helper and not an examiner. The materials which the experimental teachers wanted were made available to them immediately. Close cooperation and guidance were the two functions of the investigator. The working relationship was extremely good between the teachers and the investigator. To the investigator's knowledge, the experimental teachers never felt themselves helpless or left at large because of the lack of materials, instructions, guidance or encouragement.

The role of the investigator as a consultant and facilitator is significant. This role is incorporated in data interpretation later in this study.

Chapter 4

ANALYSIS

The battery of pre- and post-tests included three tests each. These were the Torrance Tests of Creative Thinking (Figural), Torrance Tests of Creative Thinking (Verbal), and the test of Observation and Classification made by the investigator. A brief description of these tests is presented in order to understand the statistical implications of the tests.

DESCRIPTION OF TORRANCE TESTS OF CREATIVE THINKING FIGURAL FORMS A AND B[1]

Forms A and B are a collection of three activities each -- Picture Construction, Picture Completion, and Parallel Lines (Form A) or Circles (Form B). In the first activity the stimulus is given in the form of a shape and the examinee is asked to form an unusual picture in which a particular shape is an important part. The shape can be moved anywhere on the two pages and be pasted at a desired place. In the Picture Construction activity, the subject tries to find a purpose for something that has no definite purpose and to elaborate on it to achieve the purpose.

The second or Picture Completion activity is in the form of ten

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[1] E. Paul Torrance, "Torrance Tests of Creative Thinking, Norms-Technical Manual Research Edition," (Princeton: Personnel Press, Inc., 1966), pp. 14-16.

incomplete shapes, each of which is to be completed in picture forms. The Picture Completion activity "calls into play the tendency toward structuring and integrating." For producing an unusual and original response, the subject has to control his tension long enough to make the mental leap necessary to get away from the obvious and commonplace response.

The activity of Parallel Lines in Form A or Circles in Form B is in the form of 30 to 36 shapes of either parallel lines or circles. The subject is asked to make as many unusual pictures with the help of these shapes as he can. These activities are called Repeated Figures Activity by the author of the test. The parallel lines are open figures and elicit the "creative tendency to bring structure and completeness to whatever is incomplete." The circles are closed figures and require the ability to disrupt or destroy an already completed form.

The Figural Forms A and B were scored locally by individuals who familiarized themselves with scoring procedures as laid out in the scoring manuals. The scoring manuals are very detailed and specific in the instructions.[2] The scorers were not told whether papers being scored were from control or experimental classrooms. Two scores of Originality and Elaboration were obtained for the Picture Construction activity. The Picture Completion and Repeated Figures Activity (Parallel Lines in Form A and Circles in Form B) were scored each for Fluency, Flexibility, Originality and Elaboration. Raw scores were

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[2]The coefficients of reliability between the scores of inexperienced and the experienced scores were computed by the author of the test. The coefficients of reliability were found to be consistently in excess of .90.

converted to T-scores. On all four, measurements according to T-scores conversion tables were provided with the manual.

TORRANCE TESTS OF CREATIVE THINKING

VERBAL FORMS A AND B[3]

The two forms of the test have parallel activities. Each of them has seven activities. The first three activities are based on a figure given in the beginning. First of all, the instructions are deliberate about asking all possible questions about the picture. However, obvious questions which can be answered just by looking at the picture are discouraged. This Asking activity attempts to measure "the subject's ability to become sensitive to what is unknown, to gaps in knowledge, because the questions asked must be those that cannot be answered by looking at the picture." The next two activities are Guess Causes and Guess Consequences. The subject is asked to guess all the causes for what he saw in the picture and asked questions about. Then the activity motivates the subject to imagine the consequences of the event shown in the picture. "The Guess Causes and Guess Consequences activities are designed to reveal the subject's ability to formulate hypotheses concerning causes and effect."

The fourth activity is the Product Improvement activity. A picture of a toy and/or a real toy are provided the subject. The activity involves suggesting maximum ideas which would make the toy more amusing to children. "It permits them to 'regress in the service

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[3]Torrance, op. cit., pp. 10-13.

of the ego' and enables them to play with ideas that they would not dare express in a more serious task." In the individual administration, as was the case in the study, "it provides an object for manipulation, making obvious certain aspects of the creative process in children."

The next two activities are based on cardboard boxes (Form A) and tin cans (Form B). The fifth activity is an attempt to list all possible unusual uses of the object. Both the objects (tin cans and cardboard boxes) tend to "create in many individuals rigid sets that are difficult to overcome. . . . The task is in part a test of ability to free one's mind of well-established set." The following activity is to enumerate the "unusual questions" about the object described in the previous activity. The author of the test believes that this activity aims to find "Divergent Power" of subjects.

The "Just Suppose activity" is in the form of a picture showing a discrepancy. The subjects are asked to imagine all of the things that would happen if the discrepancy came true.

Scoring is done on three criteria -- Fluency, Flexibility, and Originality for the "Asking," "Guess Causes," "Guess Consequences," "Product Improvement," "Unusual Uses," and "Just Suppose" activities. The "Unusual Questions Activity" was scored for fluency and originality. The test was scored for the study by the trained staff at the University of Georgia, at Athens, Georgia under the direction of the author of the test, E. Paul Torrance.

TEST OF OBSERVATION AND CLASSIFICATION

Based on the argument developed in Chapter 2, that process oriented education enhances creativity and third graders grasp that concept of observation and classification, this test was intended to test these two processes. The subjects were given an object and asked to record all their observations about it. The other activity was in the form of 21 different objects in a paper bag. The subjects were asked to classify these objects in the maximum possible ways. None of the test activities resembled any specific activity in ESS materials.

The activity on observation was scored for fluency, each response being given one mark. The classification activity was scored for flexibility. Each criterion employed by the subject for classification of objects was regarded as one score on flexibility. The procedure and guide for scoring this test has been developed by the investigator and is presented in Appendix E. The scoring was done by the investigator himself without identifying children if they were from experimental or control classrooms.

STATISTICAL ANALYSIS

Statistical analysis on nine sub-tests was conducted to verify the three hypotheses mentioned in the previous chapter. These sub-tests were: Figural Fluency, Figural Flexibility, Figural Originality, Figural Elaboration, Verbal Fluency, Verbal Flexibility, Verbal Originality, Fluency and Flexibility on Observation and Classification. The following table shows the relation of these sub-tests with the hypotheses.

Table 1

Hypotheses, Tests and Sub-tests

Hypothesis 1	Torrance Tests of Creative Thinking (Verbal Forms)	1. Verbal Fluency 2. Verbal Flexibility 3. Verbal Originality
Hypothesis 2	Torrance Tests of Creative Thinking (Figural Forms)	4. Figural Fluency 5. Figural Flexibility 6. Figural Originality 7. Figural Elaboration
Hypothesis 3	Test of Observation and Classification	8. Fluency 9. Flexibility

Raw scores on the seven criteria on both the figural and verbal forms of the Torrance Tests of Creative Thinking were converted into T-scores with the help of the T-scores conversion table accompanying the tests.[4]

Analysis of covariance was performed separately for all the nine scores. The pre-test scores were used as covariates as a means of testing the null hypotheses related to the research hypotheses. It was a one-way analysis applied to what was really a two-way design. Two factors involved in the data were the treatment and school factors and there were two levels for each factor.

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[4]Tables for converting raw scores to standard or T-scores are presented in the manual of the tests for each of the scores for each of the tests (Verbal Form A, Verbal Form B, Figural Form A, and Figural Form B). The T-score conversion tables offered with the test are based on the test performances of fifth grade pupils who took all four of the tests within a two-week period of time. The author of the tests has "found that the T-scores based on the fifth grade are rather satisfactory at all education levels." The mean is a T-score of 50 and a standard deviation equals 10 points.

There were two main reasons for not running a two-way analysis for such a design. First, the program which could operate such an analysis was not available at the Computer Center of Western Washington State College. Second, a two-way analysis of covariance involving interaction as well as main effect factors is valid only when a highly restricted set of assumptions is true, such as "independence of subjects" and "homogeneity of regression."[5]

In a quasi-experimental study, such as this one, it was not reasonable to accept all such assumptions. It seemed of limited value to carry out a two-way analysis of covariance in the absence of accepting all the assumptions. For the purpose of this study, however, one-way (four levels) analysis of covariance was helpful. This method of analysis was used, first, in order to compensate partly for any pre-existing differences among intact groups. Secondly, such analysis provided more powerful analysis by utilizing information gained from the pre-tests.

Under the circumstances, in addition to one-way analysis of covariance, 2 x 2 descriptive summary tables for class mean scores were set up to observe data trends. F-ratios found from analysis of covariance were useful in order to discover if differences among class means were much greater than would be expected by chance had, in fact, the groups been randomly divided and the null hypotheses true.

The descriptive summary tables were essential for the interpretation of results. From the study of these tables, the changes

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[5]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill), pp. 578-621.

could be observed directly from pre- to post-tests on the variables of school and treatment. Attention was focused to inspect the post-test means which had been adjusted by analysis of covariance (compensation for pre-existing pre-test differences).

Separate statistical tests were performed on each sub-test (nine sub-tests). It is difficult to interpret actual significance levels from repeated statistical tests, since the .05 significance level fixed for the study is valid for only one analysis at one time. However, some useful information could be extracted from repeated tests. If all the tests show significant positive or negative results, the hypotheses could be accepted with practically no reservation. Even if a pattern is found in most of the sub-tests, there is a strong reason for supporting the results. However, when only one or two sub-tests show results at the .05 significance level, there is not much support for respecting the hypotheses. In this case, the probability that the difference was caused by chance is greater than .05.

In the following pages, statistical results of different sub-tests have been tabulated.

Table 2

Analysis of Covariance for Fluency (Verbal)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	509.063	3	603.943	7.25[a]
Within	26	113.832	25	83.307	

[a]2.99 is required to be significant at .05 level.

Table 3

Class Mean Scores for Fluency Verbal

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	43.25	42.00	42.62	
Other	44.00	46.29	45.14	
Overall School Means	43.62	44.14		Overall Mean = 43.88

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	61.63	51.00	56.31	
Other	47.00	42.57	44.78	
Overall School Means	54.31	46.78		Overall Mean = 50.54

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	67.01	57.27	62.14	
Other	51.85	45.79	48.82	
Overall School Means	59.43	51.53		Overall Mean = 55.48

Table 4

Analysis of Covariance for Flexibility (Verbal)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	424.542	3	437.276	5.121[a]
Within	26	100.688	25	85.391	

[a] 2.99 is required to be significant at .05 level.

Table 5

Class Mean Scores for Flexibility Verbal

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	51.38	50.71	51.04	
Other	47.50	53.29	50.39	
Overall School Means	49.44	52.00		Overall Mean = 50.72

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	61.75	55.00	58.37	
Other	49.75	44.14	46.94	
Overall School Means	55.75	49.57		Overall Mean = 52.66

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	62.30	55.79	59.04	
Other	51.72	43.99	47.85	
Overall School Means	57.01	49.89		Overall Mean = 53.45

Table 6

Analysis of Covariance for Originality (Verbal)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	622.208	3	781.679	6.543[a]
Within	26	147.399	25	119.462	

[a]2.99 is required to be significant at .05 level.

Table 7

Class Mean Scores for Originality Verbal

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	62.38	61.14	61.76	
Other	65.50	69.43	67.46	
Overall School Means	63.94	65.28		Overall Mean = 64.61

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	74.50	70.00	72.25	
Other	60.75	54.14	57.44	
Overall School Means	67.62	62.07		Overall Mean = 64.84

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	75.56	71.55	73.55	
Other	60.56	52.40	56.48	
Overall School Means	68.06	61.97		Overall Mean = 65.01

Table 8

Analysis of Covariance for Fluency (Figural)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	414.333	3	466.342	4.397[a]
Within	68	110.796	67	106.047	

[a]2.75 is required to be significant at .05 level.

Table 9

Class Mean Scores for Fluency Figural

Pre-test Means				
	School 1	School 2	Overall Treatment Means	
Experimental	48.72	47.81	48.26	
Other	42.40	47.72	45.06	
Overall School Means	45.56	47.76		Overall Mean = 46.66

Post-test Means				
	School 1	School 2	Overall Treatment Means	
Experimental	46.94	49.90	48.42	
Other	49.87	39.72	44.79	
Overall School Means	48.40	44.81		Overall Mean = 46.60

Post-test Means Adjusted According to Covariance Analysis				
	School 1	School 2	Overall Treatment Means	
Experimental	46.32	49.55	47.93	
Other	51.11	39.39	45.25	
Overall School Means	48.71	44.47		Overall Mean = 46.59

Table 10

Analysis of Covariance for Flexibility (Figural)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	187.604	3	180.0	3.004[a]
Within	68	60.233	67	59.924	

[a]2.75 is required to be significant at .05 level.

Table 11

Class Mean Scores for Flexibility Figural

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	54.11	52.57	53.34	
Other	49.13	53.06	51.09	
Overall School Means	51.62	52.81		Overall Mean = 52.21

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	47.89	50.33	49.11	
Other	44.87	43.28	44.07	
Overall School Means	46.38	46.80		Overall Mean = 46.59

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	46.96	49.60	48.28	
Other	44.57	42.48	43.52	
Overall School Means	45.76	46.04		Overall Mean = 45.90

Table 12

Analysis of Covariance for Originality (Figural)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	559.542	3	582.806	2.128[a]
Within	68	271.460	67	273.927	

[a]2.75 is required to be significant at .05 level.

Table 13

Class Mean Scores for Originality Figural

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	56.67	62.24	59.45	
Other	52.73	61.33	57.03	
Overall School Means	54.70	61.78		Overall Mean = 58.24

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	87.00	79.52	83.26	
Other	73.93	84.78	79.35	
Overall School Means	80.46	82.15		Overall Mean = 81.30

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	84.85	77.86	81.35	
Other	71.44	83.03	77.23	
Overall School Means	78.14	80.44		Overall Mean = 79.29

Table 14

Analysis of Covariance for Elaboration (Figural) •

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	115.688	3	99.132	1.358[a]
Within	68	78.859	67	72.973	

[a]2.75 is required to be significant at .05 level.

Table 15

Class Mean Scores for Elaboration Figural

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	37.28	44.19	40.73	
Other	41.27	43.83	42.55	
Overall School Means	39.27	44.01		Overall Mean = 41.64

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	42.72	47.14	44.93	
Other	44.47	41.56	43.01	
Overall School Means	43.59	44.35		Overall Mean = 43.97

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	44.52	47.11	45.81	
Other	45.21	41.62	43.41	
Overall School Means	44.86	44.36		Overall Mean = 44.61

Table 16

Analysis of Covariance for Fluency
(Observation and Classification)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	751.880	3	705.52	23.371[a]
Within	55	35.929	54	30.18	

[a] 2.78 is required to be significant at .05 level.

Table 17

Class Mean Scores for Fluency
Observation & Classification

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	10.33	11.10	10.71	
Other	11.09	8.81	9.95	
Overall School Means	10.71	9.95		Overall Mean = 10.33

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	25.25	14.20	19.72	
Other	10.82	7.75	9.28	
Overall School Means	18.03	10.97		Overall Mean = 14.50

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	27.41	15.92	21.66	
Other	12.54	10.92	11.73	
Overall School Means	19.97	13.42		Overall Mean = 16.69

Table 18

Analysis of Covariance for Flexibility
(Observation and Classification)

	Degrees of Freedom	Mean Square (Analysis of Variance)	Degrees of Freedom	Adjusted Mean Square (Analysis of Covariance)	F
Between	3	37.597	3	43.42	6.302[a]
Within	55	7.557	54	6.89	

[a]2.78 is required to be significant at .05 level.

Table 19

Class Mean Scores for Flexibility
Observation & Classification

Pre-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	2.50	2.30	2.40	
Other	3.09	2.56	2.82	
Overall School Means	2.79	2.43		Overall Mean = 2.61

Post-test Means

	School 1	School 2	Overall Treatment Means	
Experimental	5.92	5.55	5.73	
Other	3.00	2.88	2.94	
Overall School Means	4.46	4.21		Overall Mean = 4.33

Post-test Means Adjusted According to Covariance Analysis

	School 1	School 2	Overall Treatment Means	
Experimental	7.08	6.83	6.95	
Other	3.80	4.00	3.90	
Overall School Means	5.44	5.41		Overall Mean = 5.42

Table 20

Summary of F-Ratios

Title	F-Ratio	"p"
Fluency Figural	4.397	< .01
Fluency Verbal	7.25	< .005
Flexibility Figural	3.0	< .05
Flexibility Verbal	5.121	< .01
Originality Figural	2.128	< .2
Originality Verbal	6.543	< .005
Elaboration Figural	1.358	< .3
Fluency Observation & Classification	23.371	< .001
Flexibility Observation & Classification	6.3	< .005

SUMMARY

By looking at the analyses, it could be summarized that the results of seven tests out of a total of nine were significant at .05 level. These included Figural Fluency, Figural Flexibility on the Figural form of the Torrance Tests of Creative Thinking; Verbal Fluency, Verbal Flexibility, Verbal Originality on the Verbal form of the Torrance Tests of Creative Thinking; and Fluency and Flexibility scores on the investigator-made tests of Observation and Classification. By looking at the descriptive class mean score tables combined with the information from analysis of covariance, the judgments were made about the likely significant variable for gains.

The tests for which there were non-significant findings included Figural Originality and Figural Elaboration on the Figural form of the Torrance Tests of Creative Thinking. No further examinations of descriptive tables were carried out in these two cases.

The test which showed significant analysis of covariance results but for which the treatment variable difference was small and minor in comparison to school or interaction factor included Figural Fluency on the Figural form of Torrance Tests of Creative Thinking. By examining the descriptive table of Figural Fluency, it was revealed that the difference on school variable was greater than the treatment. The mean was less for the experimental group in one school and greater in the other as compared to the control group. Some kind of interaction seemed apparent. Mean difference relation to interaction was found out by adding diagonal cell means together and subtracting one

from the other. Perhaps, the interaction between two variables was more strongly responsible for the significant F-ratio than any single variable by itself. The dominance of interaction factor does not rule out the possibility of treatment variable entirely but provides weak support to it.

The tests which showed analysis of covariance results significant with treatment differences substantial and true for both schools, and presumably a major contributory factor to significance, included the following six tests. These were Figural Flexibility on the Figural form of the Torrance Tests of Creative Thinking; Verbal Fluency, Verbal Flexibility, Verbal Originality on the Verbal form of the Torrance Tests of Creative Thinking; Fluency, and Flexibility scores on the investigator-made test of Observation and Classification.

The above mentioned tests which supported the hypotheses revealed some interesting patterns. The children in experimental classrooms seemed to have gained considerably on the verbal ability to communicate creatively. The high scores of these children on Fluency and Flexibility measure on Figural, Verbal, and Observation and Classification tests indicated that the treatment developed considerable ability in more diverse ways of thinking.

The data revealed that children who received ESS instruction in School 1 scored higher than their counterparts in School 2 on six out of nine sub-tests. These were: Verbal Fluency, Verbal Flexibility, Verbal Originality, Figural Originality, Observation and Classification Fluency and Flexibility. On the rest of the three sub-tests,

which are Figural Fluency, Figural Flexibility, and Figural Elaboration, the children from experimental classroom in School 2 scored higher than others. The teacher who conducted ESS instruction in School 1 was aware of the nature of materials before the study started, as referred to in Chapter 3.

Chapter 5

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

Conclusions will be drawn here from the data described in the previous chapter. The author is aware that the data were gathered under certain limitations. The schools and teachers were not selected randomly. To assign children to different groups through randomization was not possible under the circumstances. No attempt was made to check the interaction between the children of the experimental and the control group during the period of the study.

The following conclusions of the study should be considered in the light of the above-mentioned limitations.

HYPOTHESIS 1

The children subjected to instruction in Elementary Science Study (ESS) materials will show higher scores on the verbal form of Torrance Tests of Creative Thinking than those who do not have such instruction.

To verify this hypothesis, the Verbal forms of the Torrance Tests of Creative Thinking were used during pre- and post-test. The test was scored for three measures or sub-tests, namely: Verbal Fluency, Verbal Flexibility, and Verbal Originality. Their results are as follows.

Verbal Fluency

The data on fluency measured by the Verbal form of the Torrance Tests of Creative Thinking show a consistent pattern. The F-ratio is significant at the .005 level. The descriptive summary of adjusted class mean scores reveals that the experimental groups scored higher than the control groups in both schools. Therefore, of the variables being examined, the treatment variable was quite significant in determining the results. Interestingly, when the pre-test scores were examined, the experimental groups were slightly inferior to the control groups. In addition to this, the school factor may also be responsible for the final data. School 1, which was lower at the pre-test time than School 2, made gains on the post-test in both the experimental and the control groups.

Verbal Flexibility

The data presented in Chapter 4 on Verbal Flexibility, as measured by the Verbal form of the Torrance Tests of Creative Thinking, have some interesting features. The F-ratio is significant at .01 level. The adjusted mean scores are consistently higher in both schools for the experimental group. This indicates that the treatment factor could be regarded as an important factor. The other possibility, of relatively less importance than the treatment variable, is the variable of the school. School 1 was superior to School 2 at the post-test time, but not so much as the experimental group to the control group.

Verbal Originality

The data were obtained from the Verbal form of the Torrance Tests of Creative Thinking. The F-ratio was significant at .005 level. The summary table of the adjusted mean scores suggest that the treatment variable was chiefly responsible for the change in scores from the pre- to post-tests. The variable of the school may also be somewhat contributory to this effect.

From the above interpretations, a conclusion is drawn to accept Hypothesis 1.

HYPOTHESIS 2

The children subjected to instruction in Elementary Science Study (ESS) materials will receive higher scores on the Figural form of the Torrance Tests of Creative Thinking than others who do not have instruction in Elementary Science Study materials.

The Figural forms of the Torrance Tests of Creative Thinking were used in the pre- and post-test in order to verify this hypothesis. The test was scored for Figural Fluency, Figural Flexibility, Figural Originality, and Figural Elaboration. The conclusions on these subtests are described below.

Figural Fluency

The data presented in the last chapter on Fluency, measured by the Figural form of the Torrance Tests of Creative Thinking, show a significant pattern. The F-ratio is significant at .01 level. However, the descriptive summary table of adjusted class means shows that

in School 1 the non-experimental or control group gained more than the experimental group. On the contrary, the experimental group scored higher in School 2 than the control group. The total mean of the experimental groups in Schools 1 and 2 is higher than the control groups in the two schools. It could be inferred from this that some sort of interaction between the two variables--school and treatment--played some role towards significant results.

Figural Flexibility

The F-ratio is significant at the .05 level on the Flexibility score. All the groups scored lower on the post-test than the pre-test, but the adjusted post-test scores indicate that the experimental group experienced significantly less decrease than the control group. Of the two variables, treatment seemed to be clearly responsible for the overall difference.

Figural Originality

The data on this measure were obtained from the Figural form of the Torrance Tests of Creative Thinking. The F-ratio is significant at .2 level, which is not acceptable for the study. Both the variables of the school and treatment seem to be non-significant for the change observed in the adjusted mean scores table. There is, however, a very slight possibility of some kind of interaction between these two variables.

Figural Elaboration

The Elaboration scores were obtained on the Figural form of the Torrance Tests of Creative Thinking. The F-ratio is non-significant

statistically. The measured effect of the two variables examined do not fall in a consistent pattern.

Only two sub-tests, Figural Fluency and Figural Flexibility, are significant at .05 level. Therefore, this hypothesis is not accepted. However, upon studying the descriptive class mean score tables for the other two sub-tests, Figural Originality and Figural Elaboration, the evidence seems to be more in favor of accepting it than rejecting it. The tables of Post-test Means (adjusted according to covariance analysis) suggest that, on both these sub-tests, children in the experimental classrooms scored higher than others in the control classrooms.

HYPOTHESIS 3

The children who have had instruction in Elementary Science Study (ESS) materials will show higher fluency and flexibility on the test of Observation and Classification than those who do not receive instruction in Elementary Science Study materials.

The test of Observation and Classification, made by the investigator, was administered in the pre- and post-test in order to verify this hypothesis. The test was scored for fluency and flexibility.

Fluency on the Test of Observation and Classification

These scores were obtained on the investigator-made test of Observation and Classification. The F-ratio is significant at the .001 level. The Adjusted Post-test Means suggest that the treatment variable was a very strong variable in these data. The school variable was relatively less contributory to the overall change.

Flexibility on the Test of Observation and Classification

Flexibility scores were obtained on the investigator-made test of Observation and Classification. The F-ratio is significant at the .005 level. The treatment appears to be clearly related to the change in scores. The two schools were about the same at the time of the post-test.

Based on the above, the conclusion is drawn to accept Hypothesis 3.

An important observation is made regarding the fluency and flexibility abilities of children. These two abilities were scored for all the three tests (Torrance Tests of Creative Thinking Verbal and Figural, and the test of Observation and Classification). Upon studying scores on the three tests, it can be observed that children in the experimental classrooms scored higher for fluency and flexibility at .05 significance level on all of them than other children in the control classrooms. It seems that the Elementary Science Study materials are quite useful in developing the fluency and flexibility abilities of children.

DISCUSSION

A feasible assumption is that certain changes in the experimental classrooms must have taken place between the pre- and post-test which later contributed to the degree of statistical significance. In the following paragraphs an attempt will be made to discuss what these changes may have been in terms of their nature and impact on children's development.

Statistically the data indicate that the two factors of treatment and school were chiefly responsible for such changes. The treatment which was different in the experimental group from the control group included at least four instructional units of Elementary Science Study materials. These units were based on topics which are of general interest to children. The title and content of the units do not seem to be very important for the development of children's creativity. A closer look reveals two reasons.

First, the test activities which constituted the pre- and post-test batteries were not based on any of the units used in the class per se. The authors of the tests had not used ESS materials to choose the content of the test items. The emphasis during the testing was to look for the abilities which could be regarded as creative abilities rather than to look exclusively for any knowledge stored in the brain.

Second, there were some similar activities to ESS materials (strictly from the point of view of knowledge), such as mobiles and observing changes carried out in the control classrooms.

What seems to be more responsible for the development of the creativity of children as shown by the data is the approach the teachers used in the experimental classrooms. ESS materials are so interesting and engrossing to children that they start doing things which are natural and liked by them. ESS materials provide the content area in which children can operate. The teacher provides the motivation and the environment for the activity in the classroom. Due to the considerable degree of flexibility in ESS materials, the approach to learning is always decided by the teacher or pupils. The book in

itself does not direct or demand any particular approach by the teachers.

The philosophy of ESS materials advocates the need for "messing about" and freedom for children. The free exchanges of thinking, doing, manipulating, communicating and sharing should be allowed in ESS oriented classrooms. Perhaps the teachers in the experimental group were convinced that this was the proper route to follow. They allowed the children to work with their materials independently and freely. The activities suggested in the ESS materials became so intriguing that they worked ambitiously on them. When they became stuck with the problem activity they found solutions by experiencing the processes of observation, constructing, drawing, cutting, piercing, joining, taking apart, rubbing and so on. They had the freedom, approval and materials for doing all such things.

Another factor which may have made some contribution was the availability of guidance and the physical materials for the teachers. During the period of the study, the investigator approached the teachers as a helper and not as an authority. He helped the teachers to identify their strong and weak points in teaching ESS materials. He came up with suggestions that could be followed in succeeding days. Teachers accepted him as a friend and the ESS materials proposed by him as suitable materials for their classrooms. The children accepted him as a frequent student visitor from the college. The investigator enjoyed the children for their vitality, freshness, and intensive curiosity. At times the investigator reaffirmed to himself the conviction that this zeal, dedication, and interest in work must be kept up at

least during the period of the study. The teachers and the investigator discussed together how this could be accomplished, both recognizing its importance. Once this was done, the investigator felt that there was no problem in translating the decisions made into practice through the teachers.

The close working relationship between teacher and investigator was extremely valuable in determining the course of the study. All the three components, teacher, children and investigator, found the experience interesting, intriguing and stimulating. The basic premise of faith in each other was well established even during the first two weeks of the study.

In the investigator's assessment, which is only one possible explanation for the considerable changes observed, ESS provided the stimulus, the teacher provided the enthusiasm, the investigator provided the physical materials, direction and moral support, and the children provided the challenge. No single factor was responsible for the remarkable development shown in the data. All the factors combined made the difference.

This study, under the conditions described earlier, indicated that several components of creativity can be increased through appropriate training. The training in certain processes has been found to be useful for developing creativity among the experimental subjects of this study. Elementary Science Study materials provide a wide scope for learning processes. If teachers become convinced of the philosophy of Elementary Science Study (ESS) materials and use them in their classrooms accordingly, these materials can become very effective for

promoting creativity in children. The guidance and assistance available to teachers are very important factors in making a program successful. ESS materials, with teacher's guides and kits, become tremendously helpful when the teachers are able to discuss their doubts, strategies, and successes with someone already familiar with them. The availability of suggestions and guidance are perhaps as important as the physical materials.

Regarding the close working relationship among different persons involved in the study, there is no empirical evidence to show its undesirability. On the other hand, the investigator and his associates have certainly observed that the close rapport and working relationship among all persons involved, especially between the investigator and the teachers, make the conducting of the study considerably more effective, smooth and easy.

RECOMMENDATIONS

The investigator feels that this study has raised several questions which should be looked into thoroughly in the future. Some of these are:

1. The study should be repeated for suitable populations before making generalizations on its conclusions.

2. The use of Elementary Science Study materials should be made for a period of one year at least to assess their impact on children's development in general and creativity in particular.

3. Based on the "structure of Intellect" or any other model of creativity, longitudinal studies should be conducted to examine the

effectiveness of Elementary Science Study materials for the progressive and sequential development of creativity among children in elementary schools.

4. Studies should be conducted to establish the effectiveness of science instruction in promoting creativity in elementary schools.

5. The nature of the creativity "slump," observed in fourth grade children by other researchers, should be studied thoroughly by using ESS materials. There may be a possibility that children will experience very little or no effects of "slump" in an ESS classroom.

BIBLIOGRAPHY

BIBLIOGRAPHY

Anderson, H. H. (ed.). Creativity in Childhood and Adolescence. Palo Alto: Science and Behavior Books, Inc., 1965.

Anderson, Ronald D., and others. Developing Children's Thinking Through Science. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970.

Aschner, Mary Jane, and Charles E. Bish (eds.). Productive Thinking in Education. New York: Carnegie Corporation, 1968.

Association of Supervision and Curriculum Development. Perceiving, Behaving, Becoming. 1962 Yearbook. Washington, D.C.: National Education Association, 1962.

Balzer, LeVon. Personal interview. December 15, 1971.

Beard, Ruth M. An Outline of Piaget's Developmental Psychology for Students and Teachers. New York: Basic Books, Inc., 1969.

Bills, Frank Lynn. "Developing Creativity Through Inquiry," Science Education, Vol. 55 (No. 3, 1971), pp. 417-21.

Bloom, B. S. Taxonomy of Educational Objectives, Handbook I: Cognitive Domain. New York: David McKay Company, Inc., 1956.

Bruner, J. S. Toward a Theory of Instruction. New York: Norton and Co., Inc., 1967.

Buhl, H. R. Understanding the Creative Engineer. New York: American Society of Mechanical Engineers, 1961.

Christensen, P. R., J. P. Guilford, and R. C. Wilson. "Relation of Creative Responses to Working Time and Instructions," Journal of Experimental Psychology, Vol. 53 (Feb., 1957), pp. 82-88.

Cole, Henry P. "Process Curricula and Creativity Development," Journal of Creative Behavior, Vol. 3 (Fall, 1969), pp. 243-59.

Corita, Sister. Footnotes and Headlines. New York: Herder and Herder, 1967.

Covington, M. V., R. D. Crutchfield, and L. P. Davis. Teacher's Guide to the Productive Thinking Program. Berkeley: University of California, 1967.

Ebel, Robert L. (ed.). Encyclopedia of Educational Research. London: The Macmillan Company, 1969.

Education Development Center. Introduction to the Elementary Science Study. Newton, Massachusetts: Education Development Center, 1966.

Freeman, James, and others. Creativity: A Selective Review of Research. London: Society for Research into Higher Education, 1968.

Gage, N. L. (ed.). Handbook of Research on Teaching. Chicago: Rand McNally & Company, 1965.

Gagne, R. M. "Learning Hierarchies." Presidential address, American Psychological Association, San Francisco, California, August, 1968.

Gaier, Eugene L., and Marie Dellas. "Concept Formation and Creativity in Children," TIP, Vol. 10 (April, 1971), pp. 117-23.

Gallagher, James J. Teaching the Gifted Child. Boston: Allyn and Bacon, 1964.

Gardner, John W. Self-Renewal. New York: Harper & Row, 1971.

Getzels, J. W., and P. W. Jackson. Creativity and Intelligence: Explorations with Gifted Students. New York: John Wiley & Sons, 1962.

Gordon, William J. J. Synectics: The Development of Creative Capacity. New York: Harper & Row, 1961.

Gowan, J. C., and E. P. Torrance (eds.). Educating the Ablest. Itasca, Illinois: Peacock Publishers, Inc., 1971.

Gowan, John Curtis, and others (eds.). Creativity: Its Educational Implications. New York: John Wiley & Sons, 1967.

Goyal, K. C., and Piyush Swami. Research Ideas for Science Projects. New Delhi: NCERT, 1967.

Gruber, Howard A. (ed.). Contemporary Approaches to Creative Thinking. New York: The Atherton Press, 1962.

Guilford, J. P. "Creativity," American Psychologist, Vol. 5 (Sept. 1950), pp. 444-54.

Guilford, J. P. "Creative Thinking and Problem-Solving," Education Digest, Vol. 29 (April, 1964), pp. 29-31.

Guilford, J. P. "Potentiality for Creativity and Its Measurement," Invitational Conference on Testing Problems. New Jersey: Educational Testing Service, 1965.

Guilford, J. P. The Nature of Human Intelligence. New York: McGraw-Hill, 1967.

Hallman, Ralph J. "Can Creativity Be Taught?" Educational Theory, Vol. 14 (January, 1964), pp. 15-23.

Hallman, Ralph S. "Techniques of Creative Teaching," Journal of Creative Behavior, Vol. 1 (Summer, 1967), pp. 325-30.

Hawkins, David. "Messing About in Science," The ESS Reader. Newton, Massachusetts: Education Development Center, 1970.

Hockett, J. A. "The Significance of Creative Expression," California Journal of Elementary Education, 9:163, 1941.

Inhelder, Barbel, and Jean Piaget. The Early Growth of Logic in the Child. London: Routledge and Kegan Paul, 1964.

Kagan, Jerome (comp.). Creativity and Learning. Boston: Houghton Mifflin Co., 1960.

Lane, Mary B. "Let's Give Johnny Freedom to Make Mistakes," Childhood Education, Vol. 39 (April, 1963), pp. 380-83.

Lehman, Robert A. "The Effects of Creativity and Intelligence on Pupils' Questions in Science," Science Education, Vol. 56 (January-March, 1972), pp. 103-21.

Lindaman, Edward. Address at St. James Presbyterian Church, Bellingham, Washington. February 13, 1972. Tape available at the church.

MacKinnon, Donald W. "What Do We Mean by Talent and How Do We Test for it?" The Search for Talent: Handbook New York: College Entrance Examination Board, 1959.

MacKinnon, D. W. "Creativity in Architects," The Creative Person. University of California, Berkeley: Institute of Personality Assessment Research, 1961.

Massialas, Byron G., and Jack Zevin. Creative Encounters in the Classroom. New York: John Wiley & Sons, 1967.

McCormack, Alan J. "Effects of Selected Teaching Methods on Creative Thinking, Self-Evaluation, and Achievement of Students Enrolled in an Elementary Science Education Methods Course," Science Education, Vol. 55 (No. 3, 1971), pp. 301-7.

Mead, Margaret. "The Gifted Child in the American Culture," Journal of Teacher Education, Vol. 5 (Sept., 1954), pp. 211-14.

Mearns, Hughes. The Education of Youth in the Creative Arts. New York: Dover Press, 1958.

Moltzman, I. "Experimental Studies in the Training of Originality," Psychological Review, Vol. 67 (July, 1960), pp. 229-42.

Osborn, Alex F. Applied Imagination: Principles and Procedure of Creative Problem-Solving. New York: Scribner's, 1957.

Parnes, Sidney J., and H. F. Harding (eds.). A Sourcebook for Creative Thinking. New York: Charles Scribner's Sons, 1962.

Piaget, Jean. The Origins of Intelligence in Children. New York: International University Press, Inc., 1952.

Piaget, Jean. Six Psychological Studies. New York: Random House, 1967.

Piltz, Albert, and Robert Sund. Creative Teaching of Science in the Elementary School. Boston: Allyn and Bacon, 1968.

Raina, M. K., and Piyush Swami. "Developing Creativity Through Investigatory Projects," Teaching (September, 1969), 2-8.

Raina, T. N., and M. K. Raina. "Perception of Teachers-Educators in India about the Ideal Pupil," The Journal of Educational Research, Vol. 64 (March, 1971), pp. 303-6.

Ransom, Wayne E. "Effect of Science--A Process Approach on Creative Thinking and Performance in Selected Processes of Science in the Second Grade." Doctoral dissertation, Syracuse University, cited in an article by James T. Gallaghar, "A Summary of Research in Science Education for the Years 1968-69, Elementary School Level," Journal of Research in Science Teaching, Vol. 9 (No. 1), 1972.

Roslensky, John D. (ed.). "Creativity," a discussion at Nobel Conference, 6th, Gustavus Adolphus College, St. Peter, Minnesota. Amsterdam: North Holland Publishing Co., 1970.

Ross, J. Alan, and Ralph Thompson (eds.). Intelligence, Creativity and Learning: Proceedings of the Summer Conference. Bellingham, Washington: Western Washington State College Bulletin, 1960.

Sanders, Norris M. Classroom Questions: What Kinds? New York: Harper & Row, 1968.

Science--A Process Approach. Curriculum material developed by The American Association for the Advancement of Science. Published by The Xerox Corporation, 1967.

Shiveley, Joe E., and others. "Effects of Creativity Training Programs and Teacher Influence on Pupils' Creative Thinking Abilities and Related Attitudes," ERIC Microfich, Catalogue No. ED047332.

Sigel, Irving E., and Frank H. Hooper (eds.). Logical Thinking in Children: Research Based on Piaget's Theory. New York: Holt, Rinehart and Winston, Inc., 1968.

Taba, Hilda. "Opportunity for Creativity in Education for Exceptional Children," Exceptional Children, Vol. 29 (February, 1963), pp. 247-56.

Taylor, Calvin W., and Frank Barron (eds.). Scientific Creativity: Its Recognition and Development. New York: John Wiley & Sons, 1963.

Taylor, Calvin W. (ed.). Widening Horizons in Creativity. New York: John Wiley & Sons, 1964.

Taylor, Calvin W., and Frank Williams (eds.). Instructional Media and Creativity. New York: John Wiley & Sons, 1966.

Taylor, C. W., Lloyd Beverly, and Judy Rollins. "Developing Multiple Talents in the Classroom Through the Implementation of Research," Journal of Research and Development in Education, Vol. 4 (Spring, 1971, pp. 42-49.

Torrance, E. Paul. "Priming Creative Thinking in the Primary Grades," Elementary School Journal, Vol. 62 (October, 1961), pp. 34-41.

Torrance, E. Paul. Rewarding Creative Thinking. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965.

Torrance, E. Paul. Torrance Tests of Creative Thinking. Norms-Technical Manual. Research edition. Princeton, New Jersey: Personnel Press, Inc., 1966.

Torrance, E. Paul (comp.). Education and the Creative Potential. Minneapolis: The University of Minnesota Press, 1967.

Torrance, E. Paul. Encouraging Creativity in the Classroom. Dubuque, Iowa: W. C. Brown Co., 1970.

Williams, F. E. (ed.). Creativity at Home and in School. St. Paul, Minnesota: Macalester Creativity Project, 1968.

Winer, B. J. Statistical Principles in Experimental Design. New York: McGraw-Hill, 1962.

Witty, Paul. "Some Considerations in the Education of Gifted Children," Educational Administration and Supervision, 26:512, October, 1940.

Wolfe, Dael. "Intellectual Resources," Scientific American, 185:42, September, 1951.

APPENDIXES

APPENDIX A

LETTER DIRECTED BY PIYUSH SWAMI TO DR. RICHARD L. GREEN, ASSISTANT SUPERINTENDENT, BELLINGHAM PUBLIC SCHOOLS

June 16, 1971

Dr. Richard L. Green
Assistant Superintendent
Bellingham Public Schools
Bellingham, Washington 98225

Dear Dr. Green:

I am herewith presenting to you some of the specific requirements for conducting the research study discussed with you in the meeting on June 9, 1971.

The research design requires that two elementary schools should be selected for the study, each of which has at least two third grade classrooms. One classroom in each building will be treated as the control and another as the experimental group. The instructional work during the whole period of study in all the classrooms will be carried out by the regular teachers. For the period decided upon with mutual agreement with the administration and participating teachers, the experimental groups in both buildings will study Elementary Science Study (ESS) materials. During the same period of time the instruction in the control classrooms will be carried out as usual. A battery of pre- and post-tests will be given to children in all the four classrooms before and after starting teaching ESS materials to the experimental groups.

The investigator's role during the whole study will be solely as a guide and helper for the teachers. He will borrow all the necessary instructional kits, teacher's guides and other materials from the Science Education Center at Western Washington State College for use in the experimental classrooms and make them available to teachers. No expenses will have to be incurred by the school administration in connection with the study.

A period of six to eight weeks is proposed for the conduct of the study in the schools. However, this limit of time can be decided later with your consultation.

If there are any other questions, please let me know. I shall be most anxious to provide answers to them.

I hope you will kindly grant me the approval and cooperation in pursuing this study in the school system.

Sincerely yours,

(signed) Piyush Swami

APPENDIX B

BELLINGHAM PUBLIC SCHOOLS

ADMINISTRATIVE OFFICES ROECER SCHOOL BUILDING
DUPONT AND I STREETS
P. O. BOX 878 — TELEPHONE 734-9900
BELLINGHAM, WASHINGTON 98225

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ADMINISTRATOR OF BUSINESS AND FINANCE

August 10, 1971

BOARD OF DIRECTORS
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Mr. Piyush Swami
1310 Grant Street
Bellingham, Washington 98225

Dear Mr. Swami:

I received your letter seeking cooperation in conducting research.

After considering your proposal there are several areas requiring clarification before I could commit our district to cooperating with your project. Our ordinary procedure is to require that research projects be approved and sponsored by a college instructor. The nature of your proposal could involve curriculum changes and also would depend upon the voluntary participation of four teachers. With the information I have, I cannot be too encouraging especially since teachers participating in the program will not be available until September 8th. After this date I will help you in any way I can to secure the classrooms necessary for an approved research project.

Sincerely,

Richard L. Green
Assistant Superintendent

RLG/baa

THE UNIVERSITY OF GEORGIA
COLLEGE OF EDUCATION
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
ATHENS, GEORGIA 30601

October 16, 1971

Mr. Piyush Swami
1310 Grant Street
Bellingham, Washington
98225

Dear Mr. Swami:

I do not think that the modification for administering the verbal creativity tests as proposed in your letter of October 10, 1971, would influence the results. However, I would like to suggest for your consideration two alternative solutions and one additional suggestion for the analysis of the data that can be used with whatever administration procedure you choose.

Administer the figural tests under group conditions to all subjects but administer the verbal tests to only a sample (perhaps a random one-half) of the experimentals and controls or administer to all subjects only certain test tasks (e.g., 1, 2, 3, and 4 or 1, 2, 3, and 5). It would be wonderful if you can manage the testing of all subjects individually, but it does take considerable man hours.

Another possibility would be to administer the test tasks in 2 or 3 sittings in small groups (4, 5, or 6). You would need an administrator for each small group. I usually test an entire class at the time, letting them sit in a circle with an administrator in each group to record responses. I double the time for each test task. This procedure has the advantage of reflecting how the children function in groups in producing ideas. Usually this is the kind of practice children get in class but not on tests. The enclosed monograph by Nash and Torrance gives examples of this kind of group evaluation.

Regardless of what procedure you use, you might want to evaluate further the causal thinking manifested in Task 2. The scoring guide for this by Phillips is enclosed.

We are short on verbal norms for the third grade. For permission to use the normative data, we would be willing to score the verbal tests without charge, if you decide to give the entire verbal battery under individual conditions to either a sample or the entire study population.

Let me know, if we can assist you further.

Sincerely,

APPENDIX D

GUIDELINES FOR EXAMINERS

Creativity is a very special phenomenon that is found in all individuals regardless of age, sex and formal education. More often than not this ability is not exhibited in our actions because it demands a very peculiar environment. The critical environment makes the individual tense and is a very powerful inhibitor for any creative behavior. [redacted]formal audience which does not prescribe many "do's" and "don'ts" is most conducive to creative actions.

Following are some of the suggestions that should be used as much as possible in order to ensure the maximum success of this test. As an examiner you may use your judgment to decide a particular action so long as it remains in the area of proper environment for creativity.

1. Please do not suggest to children in any way that it is a "test" and they are examinees. Use of words such as "booklets" or "exercises" is suggested when needed to describe the test.

2. Psychological climate, both preceding and during the use of the test should be as comfortable and stimulating as possible. The atmosphere should be created in which children accept test activities as "fun" activities. Tense environment is not compelling and proper for all individuals.

3. The preliminary orientation of children is very important. An attempt should be made to arouse interest and motivate performance. Some modification of the following may be used:

I believe you will have a lot of fun doing the activities we have planned for this period. We are going to do some things that will give you a chance to see how good you are at thinking up new ideas and solving problems. They will call for all of the imagination and thinking ability you have. So I hope that you will put on your best thinking cap and that you will enjoy yourself.

Within the context of the situation, the activity should be made as non-threatening as possible.

4. After orientation, pass out the booklets (Figural). Please check that the names, et cetera, on the booklets are filled in the proper columns. In the verbal test when the use of the tape recorder will be made, please speak the name of the child in the tape before starting the testing.

5. The time limit suggested for each activity is the uninterrupted period for an activity. Please keep the time limit.

6. In case you find that children are tired after an activity, a short break may be allowed between activities.

7. Assist the children in writing titles for their drawing (Figural Activity 1).

8. After orientation, ask the children if they have any questions about the instructions. If there aren't questions, proceed with the first activity. If there are questions, attempt to satisfy them by repeating the instructions in simpler words or by elaborating upon the instructions in the booklets. Do not give examples or illustrations of "model responses."

9. If children are disturbed by not completing all the tasks in time, reassure them by saying something like this:

I notice that you are working in different ways. Some of you finished all of your drawings quickly and then went back and

added other things. Some of you finished only a few of the drawings but you made each of them tell a very complete story. Continue to work in whatever way is natural and comfortable for you.

10. The use of the tape recorder should not be inhibitive for a child. Perhaps a statement like the following would make a child more comfortable in the beginning:

> We have a tape recorder here which we shall use to record our conversation. This way, we can listen to our conversation at a later time and it would be easy to remember whatever we say to each other today. If you like, I may run the tape for you when our conversation is over. Let us not worry about the tape recorder and do our work while the tape recorder is doing its work.

APPENDIX E

TEST OF OBSERVATION AND CLASSIFICATION

This test was made by the investigator. Two activities were included in the pre- and post-test each.

Activity #1

Observe the candle given to you and record all the observations that you make about it.

(This activity remained the same in both pre- and post-test.)

Activity #2

Divide the given objects in as many groups or piles as possible. Record all the different ways you made your groups.

(The materials used in this activity were changed in the pre- and post-test.)

Administration of the Test

The test can be administered individually or for the entire group of children. Generally, this test is suitable for third grade children (age group 8-9 years old). There is no time limit on any of the activities, but the administrator should keep track of what the children are doing. If they are not involved in a meaningful way, the next activity should be provided. If any child is unable to write, assistance may be provided by the administrator in writing down the criteria for classification or observations. The administrator should write down what the child says to him without making any suggestions

on his part.

In the beginning, a brief orientation is necessary. The administrator may use some modification of the following for this purpose:

> Today we shall have some funny things to work with. I shall give you different things to play with. Each time I shall tell you how to play with them. One of the things will be given just to look at carefully while the other will require you to divide objects in several piles or groups. I hope you will enjoy doing this.

After this the answer sheets (white lined paper sheets) should be distributed. Ask the children to write on top of it their names, age and date.

Introduce the first activity like this:

> I shall give each one of you a wax candle. Look at it carefully and then write down carefully on your sheet all that you observe about it. After you have written all about the candle, I shall light it for you. You may record some more observations when it is lighted. Then you may blow out your candle and record what you see then. Let me give you an example: Watch carefully what I am going to do now. [Administrator moves in the room to turn off the lights. Then he turns them back on and returns to his original position.] Then tell me what you saw me do just a few minutes back.

Distribute the candles, one for each child. Keep an eye on children as a safety precaution when the candles are lighted.

After the first activity is over, the second activity should be introduced.

> In the next activity, you will be given a paper bag with lots of objects in it. After you have taken them out of the bag, you will be asked to divide them in many piles according to a different way each time. Each time you have made a group, write down what kind of group it is. Let me give you an example by making different groups of children in the classroom. Suppose we want to divide the children in the classroom, here, in different groups. In what ways can we divide them in separate groups? (Elicit answers, such as according to height, color of hair or eyes, sex and so forth.)

Then distribute the paper bags, an identical bag for each

child. Ask the children to take out everything on their desks and make groups of th[illegible].

Scoring Procedure

Activity #1 - "Observation of candle" activity is scored for fluency only.

Rules

a. Count one point for each relevant observation.

b. Relevancy of an observation implies that the observation should be made in the context of the reality of the object. Observations which regard the object as fantasy or supernatural, such as "My candle is Aladdin's lamp," "My candle is for Christ," et cetera, are not regarded as relevant responses. Similarly, ideas which are not concrete are disregarded for relevancy. For example, answers such as "Not too happy," "I like him," et cetera, are irrelevant observations. No points are counted for irrelevant responses.

c. Observations described in the future tense are not counted as valid. No credit is given for them.

d. Contrasting observations, such as dirty/clean are counted as one observation.

e. Every relevant observation about any missing part of the object is counted as one point.

f. Giving different names to the object is not counted for scoring. Responses such as, "My candle's name is Burning Snoopy," "My candle is Stupid Steve," et cetera, are given no credit. However, if an observation is made about the writing, if any, on the object, one

credit is given for each such observation.

The total points on the test is the total score for fluency.

Activity #2 - Classification activities are scores for flexibility only. Each answer is checked with the following list of flexibility categories. If the response does not fit in any of the following categories, a new name may be added. After the response is located in a category, the category number is written in front of the response. When all the answers are identified with the category numbers, a count is made for the total number of categories used. Caution should be taken in counting because a single category may be used for more than one response. Each different category is counted for one point. The total points on the categories are the score for flexibility.

Flexibility Categories

1. Absorption: Water, ink, et cetera.
2. Breakable
3. Color: Different color patterns included.
4. Count: Classification criterion being the number of objects in groups.
5. Eatables
6. Edges: Sides included.
7. Flexibility: Bending and non-bending.
8. Flammable
9. Growth: Seeds, et cetera.
10. Hurt: Things that hurt body parts.
11. Length

12. Noise level: Upon dropping things on the floor, et cetera.
13. Material: Plastic, paper, et cetera.
14. Metal: Non-metals also.
15. Pairs: Identical objects in same group.
16. Rolling: Also non-rolling objects.
17. Rusting
18. Shape: Round, triangular, pointed, et cetera.
19. Shine: Also dull.
20. Size: Big, small.
21. Smell
22. Solubility
23. Strength: Strong, et cetera.
24. Stretchability
25. Support: Self-supporting, et cetera.
26. Surface: Holes, smooth, et cetera.
27. Texture: Rough, et cetera.
28. Transparent
29. Usage: Office use, cooking, et cetera.
30. Weight
31. Width or thickness

APPENDIX F

INTERVIEWS WITH TWO PARTICIPATING TEACHERS

The investigator interviewed one control and one experimental teacher in different schools after the study was over.

Control Group

The class consisted of 18 children, divided evenly. The boys were more active than the girls and became more involved in class projects. Science units covered included the solar system, the skeletal and muscular structure of the human body and the heart. Students measured themselves to see if they had grown. They counted their pulse to see if the heart pumped harder after exercise. They observed pollywogs. They studied marine ecology, which was mostly observation. She said that she really didn't do anything that the children could "get right down and experiment with."

The micro-teachers came in with small units in science and the children got to do some experiments with them. They worked with children on different kinds of moulds. One time the micro-teachers brought in a live starfish and dissected it, but the regular classroom teacher herself did not do any such thing in the classroom. She commented that she did not "think it is necessary for third grade."

There was a short unit on molecules. They burned sugar and watched it burn and bubble in order to decide if a physical or chemical change took place. They made molecules out of clay for different things.

In social studies she did more, e.g., studying American Indians and making masks . . . learning their dances. She would present an idea and the class would decide what they wanted to do. Students would bring in materials and develop their own interests. The first year she taught she wanted to follow her own ideas, but this year she learned that often the children were more interested and more involved if she let them deviate from her ideas and carry out their own.

In the class discussions she said she did sometimes get highly imaginative, "far out" answers. If it could be demonstrated that they really were in error, she would correct them in class in a discussion which led the class to follow her reasoning. She admitted that much cannot be proved and then she would suggest that in time perhaps one of them would find answers to things.

When children asked her a question that she couldn't answer, she would tell them so and suggest that they discuss how to find the answer. They usually went to an authority, such as a person, rather than an encyclopedia. She gave as an example the question, "What do we burn in our furnace at school for fuel?" The class thought it was important enough to find the answer, so they talked to the custodian. It was important to the class, but the teacher did not think it was so important to her.

About evaluation, she said she kept a grade book which she used mostly for conferences because the parents wanted specific information. She did not need the gradebook for her own information about a child's improvement. She was aware of improvement in work, behavior, and attitudes. She tried to inform her students of their individual

growth -- extrinsic rewards, she said. Praise was O.K., but not necessarily important to children, so she set up a point system and gave treats. Points were given for work turned in that was correct, and for work that was later corrected, if necessary; her point being that she wanted to encourage doing work correctly, not just doing something to get a paper turned in. She noted that the "treats" revealed some competition, which she thought was good. Sometimes she gave points for behavior, although usually it was for specifically assigned work.

Experimental Group

The children in one of the experimental classrooms were typical in age, socioeconomic background and in other ways. The group was formed in the usual manner as the other classrooms were formed at the beginning of the year.

The approach of the teacher during the study was to allow children to try out their ideas. Before ESS materials were introduced there used to be regular hours for reading, arithmetic, spelling, and so on, every day. During the conduct of the study, the children had the approval of the teacher to do, make or relate practically any new idea that occurred to them. The flexibility of the teacher coupled with her strong faith in children's capabilities were two significant ingredients that she found essential for carrying out ESS materials instruction. She agreed to both of these and practiced them extensively.

Many times, the children started their day's work with a discussion or demonstration of certain things they had observed or made with materials used in ESS units. The teacher provided motivation and

initiative to the children for organizing things, disciplining themselves when needed and taking responsibility.

Quite frequently, she found herself sitting in the corner, sometimes alone and sometimes surrounded by many kids telling her their exciting stories. When the children had difficulty in making a mobile work or a clay boat float, the teacher did not contribute any of her ideas or judgments. She mostly smiled and encouraged the children to solve their own problems.

There were times when she would suggest a few things to be done; for example, to write names on their mobiles. Situations such as this provided the children with a stimulus for trying out new styles of writing, arranging, et cetera. On a suggestion like this, Martin, a nine-year-old child, decided to cut the letters of his name on the mobile which he insisted could be read from both sides rather than writing it on both sides of the paper.

During the ESS study, the children had been interested in several useful activities which were not directly connected with the study. The environment of cooperation in the classroom encouraged six children to form a singing group which later put on a show for the rest of the class. Amazingly, the teacher did not know until quite late about this project. Margaret, who had been extremely shy before, became a very interesting and active child during the study. In a nutshell, self-discipline, freedom for learning and a strong sense of interest in every child were the chief points of the teacher's approach. Formal evaluation was not a part of the teacher's approach to teaching.